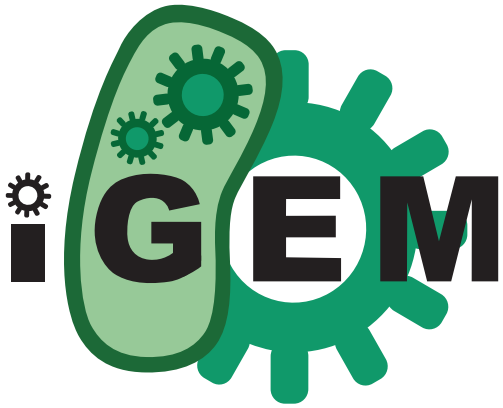

2018 GIANT JAMBOREE

JUDGING HANDBOOK

A GUIDE TO JUDGING AT THE GIANT JAMBOREE

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CHAPTER 1

INTRODUCTION

Introduction from the Executive Judging Committee

Welcome Judges! Thank you in advance for your service to iGEM this 2018 season. No matter how deeply steeped you are in our traditions of judging, there is new evolution every year. This Judging Handbook serves to help train new judges and update veteran judges. By being a public document, it also serves teams by "lifting the veil" on what once appeared (unintentionally) to be a mysterious and secret process. All members of the iGEM community can see the Handbook, having access to the same information as the judges.

The Handbook has been updated from previous years, including recent examples of award-winning work from iGEM teams. Many iGEM judges have contributed, especially the numerous case studies that can help judges better understand their task. If you are a new judge, we understand there is a lot to learn! Please do your best to go through this Handbook, and ask us questions. Be aware that some portions are more like a reference manual: not essential reading, but there for you if you need it. If you are a returning "veteran" judge, there are some changes and updates to be aware of — please make sure that you examine the material highlighted as "new" in the Handbook.

iGEM seeks to champion "Synthetic Biology based on standard parts" while embracing new ideas and innovations that may be less standard. An important development this year is the creation of the new Open Track, described more on page 94. The Open Track encompasses many of the previous Special Tracks, which are tracks which do not require teams to specifically work with standard DNA parts. These include Measurement, Policy and Practices, Art and Design, and Hardware. From year to year, the number of teams in a given Special Track has fluctuated, often to low numbers that have made it difficult to justify keeping a track going. We did not want to lose those special contributions to iGEM, or make it harder for those contributors to find a home in the iGEM community. The Open Track is also one way of extending iGEM's welcome to new approaches and ideas in synthetic biology: an Open Track team does not have to fit the description of one of those previous categories, though it certainly may do so. All Special Track teams will continue to be eligible for Special Prizes, which include Integrated Human Practices, Education & Public Engagement, Hardware, Product Design, and Measurement. Software will remain a separate Special Track.

You will find a variety of other clarifications and updates throughout the Handbook. The language describing medal requirements have been updated. We have sought to clarify this medal language (and also the judging rubric language) to reduce misunderstandings for both teams and judges. We have learned the hard way that this task is never complete, and welcome your feedback! Of the Special Prizes, please note that Applied Design has been changed to Product Design (on page 61), with a revised description. We also especially recommend reading the newly revised "On Engineering" section of the Handbook that frames the central role of engineering in iGEM starting on page 14, as well as the "What Happens When I Cast a Vote?" section on page 19.

We ask each iGEM judge to serve as a "master generalist" in evaluating all aspects of a team's work, including each special prize the team is eligible for. But the individual areas of special expertise brought by each judge are still considered valuable. For example, we seek to take judge preference into account when determining track assignments. We also ask that judges consider how to strengthen their perspective in the areas where they are less advanced. This Handbook is intended to be a resource for that effort. We also try to provide ways for judges to learn from each others' expertise, in judge panel discussions that occur after each presentation session, on the iGEM judging Slack channels, and more informally in conversations in the Giant Jamboree judging room.

The role of an iGEM judge goes beyond simply evaluating teams. We have always sought to identify areas of excellence that can be celebrated with our specific awards. But we ask that each judge also consider how their role can be used to elevate the iGEM experience for all teams, not just those receiving awards. Please think of yourself as a mentor to all teams, from the teams whose achievements amaze you, to those that have struggled with the basics.

Giving feedback to each team is an essential aspect of achieving that mentoring goal. You will have many opportunities to provide your insights to teams throughout the Jamboree — in your comments after their presentations, in your interactions at their posters, in your evaluation of the team using the judging ballot, and in the comments judges submit through the team's judging ballot. Please do as much as you can to praise what is praiseworthy, balanced with fair constructive criticism. The students have so much that they gain from your insights. Thank you again for being an iGEM judge.

With much appreciation,

The iGEM 2018 Executive Judging Committee

Peter Carr, Director of Judging

Beth Beason-Abmayr

Janie Brennan

Nils-Christian Lübke

Jessica Tang

Traci Haddock-Angelli, iGEM Headquarters Judging Co-Coordinator

Vinoo Selvarajah, iGEM Headquarters Judging Co-Coordinator

How to Use this Handbook

We have written this Handbook to help new judges get up to speed and to help experienced judges learn what has changed since they were last involved. This Handbook contains information about all the areas that you may need to evaluate, from the perspective of someone who has some biology knowledge, but may not know about software, hardware, or other areas. For this reason, there are examples from the Open and Software Tracks, but not from Foundational Advance, Environment, or the other Standard Tracks, other than when they have been finalists for examples of Excellence in iGEM on page 23.

As you will likely not be assigned teams from all the tracks described or need to evaluate every special prize, we don't recommend reading this book from cover to cover. Use this Handbook to learn how we value excellence (see past finalists, starting on page 25) and as a reference manual if you need information on a specific area.

This book contains a lot of detailed information and while we have done our best to make it as easy to understand as possible, you may still have some questions. There will be more ways to get up to speed on judging before the Jamboree, but if you would like information now, please email *judging [AT] igem [DOT]* org with "Judging Handbook Questions" in the subject line.

Thank you for volunteering to judge and from the whole Executive Judging Committee, we hope you enjoy iGEM this year!

How to Begin Your Judging Assignment

Teams are competing for 4 main prize categories in the iGEM competition:

- **Medals**
- **Special Prizes**
- **Track Prize**
- **Grand Prize**

When you begin your assignment, you will navigate to your Judge Dashboard, where you can easily access the team judging ballots to evaluate your assigned teams based on these 4 prize categories.

When using the judging ballot, the first thing you should do is evaluate the team for their medal (see the "Medals" chapter on page 37 of this handbook for more details). ***When evaluating a team, ask yourself if the team has convinced you that they have met the criteria.*** If you feel the team has merely "checked a box" stating they have met one of the medal criteria, but you feel they have not achieved enough to warrant the medal, you can choose not to award that medal. A similar philosophy should be used for all of the rubric aspects in iGEM.

Once you have decided on which medal, if any, to award the team, you can move on to evaluating the rest of the judging ballot for the team. The "Project" section of the ballot is used to determine where the team will rank in their track and how they will stack up compared to all other teams in the competition (i.e., whether they will be finalists). This category is one of the most important, and it should reflect the team's achievements as a whole.

After evaluating the "Project" section, you will move on to evaluate the team's Wiki, Presentation, Poster, and any other open sections in the ballot which will identify which special prizes the team is competing for. In most cases, the special prize will directly link to a page on the team wiki with information about what the team has achieved to warrant winning that award. *If a team has not used the required standard wiki page for that special prize, they are not eligible for that prize*.

This measure is intended to encourage teams to be clear about what awards they are competing for and for judges to easily find this important information. Time should be spent evaluating wikis, not searching them for content. For more information on this topic, see the **Pages for Awards** (http://2018.igem.org/Judging/Pages_for_Awards) on the iGEM website and Standard Pages for Awards on page 42 and on page 46.

Finally, the highest ranking teams as determined by the "Project", "Wiki", "Presentation" and "Poster" sections will become finalists and present during the Award Ceremony on Sunday. The last act of being a judge at iGEM is to vote on which teams will win the coveted BioBrick trophies. This is done in the final judges meeting following the finalist presentations on Sunday.

Points to Consider During Your Evaluations

On Feedback

Teams care about getting feedback from judges. Many teams will win awards, but most will not, simply because we do not have an award for every team (medals are a different story). This makes written feedback from the judges an important part of the competition for students. Teams will receive two types of feedback from iGEM: a summary of their scores and written comments from the judges. Any votes you cast will be summarized, anonymized, and provided to the teams. Your written comments will be aggregated and displayed on the same page as scores.

We ask judges to provide two types of written feedback on the judging ballot page for each of their assigned teams: positive feedback and constructive criticism. Written comments are important to teams, so please do write something for each of your teams, even if it is a single line on what you think of their project. We intend to release the feedback to teams within two weeks of the Jamboree. Please write feedback to teams and ensure your comments are entered by the end of the judging meeting on Saturday night during the Jamboree.

Remember you will mostly be addressing undergraduate students and, in some cases, high school students. The tone of your feedback could have an effect on their future career choice, so please choose your words wisely with this fact in mind.

On Safety 

iGEM expects all teams to demonstrate to iGEM HQ, the wider community, and to anyone interested how they working safely and securely. Teams do this by thinking carefully about and managing any risks to themselves, their colleagues, community, or the environment.

We expect everyone involved with iGEM to act responsibly throughout the competition. Please read our **Responsibilities page** (http://2018.igem.org/Safety/Responsibility) for more information on the roles and responsibilities of team members, instructors, and what you can expect from iGEM's Safety and Security Committee.

The Safety Committee has carefully reviewed Safety Forms from every team and iGEM has clearly communicated the **Safety Rules** (http://2018.igem.org/Safety#rules) and **Policies** (http://2018.igem.org/Safety/Policies) that every team must follow.

If you feel like any of the rules or safety policies have been violated by one of your teams, please contact: *safety [AT] igem [DOT] org*.

On the Responsible Conduct Committee

iGEM has a series of values that we take seriously. Integrity, good sportsmanship, respect, honesty, celebration, cooperation, and effort are some of the values that we place in high regard for all participants. iGEM students, advisers, instructors, and judges are almost always exemplary in their conduct and behavior.

However, in cases where these values are breached, a formal process to investigate is required. Allegations of misconduct are treated very seriously and are investigated by the Responsible Conduct Committee.

Please see our **Responsible Conduct Page** (http://2018.igem.org/Competition/Responsible_Conduct) for more information including hypothetical case studies.

If you think a case of misconduct requires investigation, please contact: *rcc [AT] igem [DOT] org*.

On Attribution

We care about teams telling us what they did and where their ideas originated. Each team must clearly attribute work done by the student team members on their team wiki. The team must distinguish work done by the students from work done by others, including the host labs, advisors, instructors, and individuals not on the team roster. This requirement is not about literature references - those can and should be displayed throughout the teams' wikis.

The Project Attributions page is one of the required Standard Pages for the 2018 team wiki pages. You will find that this page already exists on the team wikis at the following URL:

http://2018.igem.org/Team:Example2/Attributions.

On Engineering NEW

Engineering Biology

The engineering of biology has been at the heart of iGEM from the beginning: iGEM is an acronym for "international genetically engineered machine". However, there has been little discussion of the engineering process or what it takes to engineer biology. Here, we seek to outline the engineering method and bring it to the attention of team members and judges. Our goal is to celebrate engineering excellence while remembering that engineering comes in many different forms. Biological engineering is still in the process of developing its own discipline-specific tools and practices, and iGEM teams are an important part of that development.

What makes a good engineering project, and how should this be recognized? In the following text, we briefly provide some context on engineering biology. If you want to get straight to the practicalities, please go straight to "What to look for and reward in an iGEM project" on page 16.

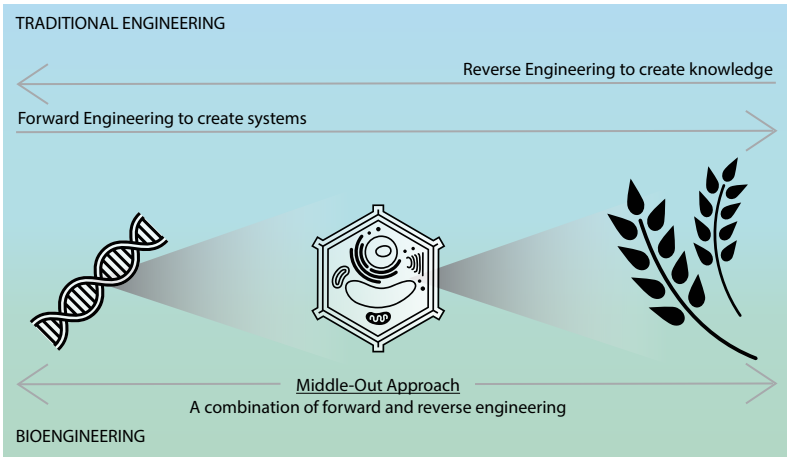
Engineering is the creative, rigorous application of knowledge about a system to solve problems or develop new technologies and products. Perhaps most importantly, engineering represents an unbiased lens through which problems can be viewed and solved.

It is a mindset and a framework that enables systematic thought about the assumptions and approximations in a design, defining both what is known and what is unknown in order to gain a view on the expected performance of a design. In this mindset, success and failure are equally valuable since they both provide answers to the question at hand and help validate or dismiss our assumptions.

"Failure is central to engineering. Every single calculation that an engineer makes is a failure calculation. Successful engineering is all about understanding how things break or fail."

— Henry Petroski

Well-established engineering fields, such as aircraft engineering, give us a good idea of how we might proceed with forward engineering biology (i.e., bottom-up synthetic biology). When building an aircraft, the engineering tools are so mature that computer aided design and simulation can entirely replace physical mockups and testing that used to be done before a full test aircraft was built. The first 777 was built directly from the in silico designs with (almost) no physical tests of subcomponents, and it was tested by fueling it up and flying it. What will we be able to do with biology when we have even a fraction of this level of predictability, and how do we get there?



Unlike many established areas of engineering, we tend not to build our systems from scratch and there are significant gaps in our knowledge of the system we wish to engineer. Imagine discovering the wreckage of an alien spacecraft and attempting to use extraterrestrial technology. To understand and wield this technology it would be necessary to reverse engineer it - to deconstruct the system to reveal its design and gain knowledge that we may re-apply elsewhere. This is similar to our relationship with biology. Therefore, our approach to engineering biology is neither fully "top-down" nor is it yet "bottom-up." Instead, our approach must be "middle-out," as Nobel laureate Sydney Brenner has thoughtfully observed. [1]

Acknowledging the necessity of our middle-out approach to engineering biology naturally leads to recognizing the importance of defining unknowns and knowns. This is core to a rigorous engineering methodology/process. Projects that excel in engineering will have demonstrated such a methodology, which is outlined below. Embracing an engineering framework will not only help iGEM teams succeed, but will accelerate the growth of the entire field of synthetic biology, which will eventually give rise to true forward engineering of biological systems.

1) Brenner S, Noble D, Sejnowski T, Fields RD, Laughlin S, Berridge M, Segel L, Prank K, Dolmetsch RE. 2001. Understanding complex systems: top-down, bottom-up or middle-out? In Novartis Foundation Symp. Complexity in Biological Information Processing, vol. 239 (eds Bock G, Goode J, editors.), pp. 150–159 Chichester, UK: Wiley

Engineering Methodology - General Outline

- Identify and demonstrate understanding of the problem
- Gather data (and cite sources) and recognize unknowns and constraints
- Select applicable guiding principles and theories
- List assumptions, approximations and simplifications
- Establish quantifiable measures of success
- Show how the problem was solved
- Validate the results
- Communicate the solution

What to look for and reward in an iGEM project

Well-engineered projects can score well in multiple parts of the judging ballot, all of which are highlighted in bold below in the bulleted list. Projects should score well if they have used clear engineering practices to define and execute their project themselves, and/or they have paved the way for others by creating well-characterized and documented parts or tools for future engineering efforts.

The best engineered projects may often not be the largest. In fact, in previous years the most impressive projects have been those that don't try to take on too much, but clearly define the problem as well as criteria for success and then engineer robust, and well-characterized solutions.

An ideal project would have success criteria defined through clear rationales and appropriate engagement with relevant stakeholders and regulators through their **Human Practices**.

Beyond whether the team achieved their goals, consider how convinced you are that the work is reproducible and a solid foundation for future work:

- Have they used **models** to meaningfully predict the behaviour of their system or guide their experimental or design choices, or alternatively have they subsequently built models that characterize and explain how their system works?
- What experiments did the team do, and were the data **replicated** or built upon?
- How rigorous are their experimental designs and **measurements**?
- How well communicated are their results (**wiki/poster/presentation**) to ensure others can build upon their work?
- Teams may have built **software** tools to help either with the simulation of their system, to design functionality or to predict behavior.
- How much attention have the team given to making the progress they have made reusable? For **parts**, or **parts collections**, how well characterized are they? Is this clearly documented on the Registry? Would you be happy to see your next iGEM team use these parts?

Overall, consider how well the team has managed to systematically apply knowledge to create a new technology or solve a problem. And additionally, consider how much effort have they put into characterization and communication of their project, to lay solid foundations for those building off their work in future.

On Human Practices NEW

Human Practices (HP) is the "bigger picture" part of iGEM. The **Human Practices Hub** (**http://2018.igem.org/Human_Practices**) contains a wealth of information, resources, and examples. Here are some important highlights for a judge.

Through their Human Practices efforts, teams must convince the judges that they have:

- ***carefully and creatively considered*** (i.e, taken a thoughtful and innovative approach to both reflect and act upon)
- **whether their projects are responsible** (i.e, conducted with care and foresight),
- **and good for the world** (i.e, can be reasonably anticipated to benefit and not harm people, and other ethical considerations like the just distribution of benefits and harms).

Human Practices involves teams exploring issues related (but not limited) to the purpose, desirability, ethics, safety, security, and sustainability of their projects. These issues are complex, often don't have simple answers, and rarely, if ever, have a 'best' solution. Teams therefore often conduct public engagement and dialogue; educating while inviting diverse public input to shape the direction of their work.

In general, we want to see how projects and teams changed in response to what was learned through Human Practices explorations.

- The idea of ***why*** their project is important and ***how*** it should be executed should be developed and answered by teams' Human Practices activities.
- When engaging stakeholders the teams should demonstrate a ***two-way dialogue*** was established throughout the design, execution, and presentation of their project
- Teams should ***not*** "proselytize" or "market" iGEM and synthetic biology by telling the community that iGEM is great and will "save the world".
- Teams should document their work in a way that others could build upon and reference any prior work that informed their approach.

Human Practices work can take many different forms. Teams have conducted environmental impact analyses, created museum exhibits, written intellectual property guides, facilitated "white hat" biosecurity investigations, and even performed street theatre. They have consulted and shared their experiences with stakeholders, constituents, and policymakers in their countries, as well as with international forums such as the United Nations.

We expect all teams to attempt Human Practices-related activities. It is a silver medal requirement, and one optional criteria for a gold medal. HP activities are evaluated as part of a team's overall project score to compete for the grand prize and individual track awards. There are also two special prizes for HP: Best Integrated Human Practices and Best Education & Public Engagement. Details on evaluating each of these prizes is found in their respective sections on page 47 and page 48.

Human Practices Criteria for Medals, Special Prizes, and Overall Project Score

- **For silver medal criteria #3**, teams should demonstrate that they have investigated "bigger picture" issues that relate to the purpose, design, execution, and presentation of their project.
- **For gold medal criteria #1**, teams should demonstrate how they have acted upon their investigations and/or activities. They should show how the design and execution of their project changed and/or evolved based on the information acquired through their Human Practices activities, particularly any changes to the "wet lab" component of the project (or the corresponding main project component for Special Tracks, e.g., software). Education projects do not meet the gold medal requirement unless the team can show how the design and execution of their project changed and/or evolved based on the information acquired through their educational activities (see "What about Human Practices activities that are not directly related to the project?" below).
- **In the Human Practices aspect of a team's overall project score**, teams should be evaluated on the overall thoughtfulness and thoroughness of their Human Practices considerations and how well it was integrated into their project.
- **The Best Integrated Human Practices** prize recognizes exceptional work based on the gold medal requirements for Human Practices. To qualify for this award, teams must demonstrate how their investigation of HP issues has been integrated into the design and/or execution of their project in a particularly thoughtful and creative way. See more details in the special prizes section starting on page 47

What about Human Practices activities that are not directly related to the project?

- **The Education & Public Engagement Prize** recognizes excellent efforts to engage communities in synthetic biology. For this prize, teams may cover topics that extend beyond a particular project and may focus on serving other communities. For example, teams may work with teachers to integrate synthetic biology into their curricula. See more details in the special prizes section starting on page 48.
- **This more "outward facing" work is important and valued but not the primary focus of the project evaluation.**

Important Notes on Activities Involving Humans

- **Teams must comply with iGEM's Safety Policies, including the human experimentation policy (http://2018.igem.org/Safety/Policies#human).** It is a team's responsibility to check with their local relevant institution/authorities as to whether or not their proposed activities (such as surveys, interviews or other types of engagements with different communities) qualify for additional oversight, and to comply with any rules (especially around vulnerable populations such as patients and minors).
- **If teams are conducting surveys and interviews,** which can be a form of experiment, we expect teams to have consulted resources and experts (including those on on the HP Hub and HP Committee members) to ensure their survey designs are valid and legitimate in addition to checking oversight policies.

Some Education & Public Engagement and Integrated Human Practices activities may be overlapping and contribute to both prize qualifications. However, because the goals of these activities differ they should be described differently on their respective wiki pages.

What Happens When I Cast a Vote?

Judges are often curious as to how their votes affect the final outcome of the Giant Jamboree. In this section, we will provide a brief overview to explain this process. You will see that every vote matters, and that your actions and decisions as a judge have a big impact!

In the judging ballot for each team each judge casts votes pertaining to medal achievement,various project-related categories, and special prizes. Each team is assigned six judges for whom we have eliminated any known conflicts of interest. In addition, judges are generally "mixed" across various teams to ensure that a particular group of six judges can draw from a variety of judging experiences and professional backgrounds.

For each ballot category, the votes from that panel of six judges are then used to determine award eligibility and winners. *Thus, it is very important to match your vote to the rubric language in the ballot as much as possible to ensure consistency across the judging body.*

Here is how the various prize-winners are determined:

Medals:

Median medal vote (rounded up if median is between medals)

Special Prizes:

Highest average score from the relevant rubric category

Track Prizes:

Highest score from a weighted average of the Project, Presentation, Wiki, and Poster categories within a track

Finalists:

Highest score from a weighted average of the Project, Presentation, Wiki, and Poster categories

Note that all final award decisions require a minimum number of votes and minimum vote score. For any given prize, if there are no teams with a sufficient number of judges voting on a prize, or with a sufficiently high score, no team will receive that prize. As you can see, it is therefore critically important that **all judges vote in all relevant ballot categories** (i.e., the ones that are made visible to you). **By abstaining from voting or voting carelessly, you could render a team ineligible for one or more prizes!**

If there is a sufficiently high number of teams in a track, prizes will be given to the highest-scoring team within each division (i.e., Undergraduate and Overgraduate)

Standard Pages for Awards

To make it easier for judges to find relevant documentation, we have created pages in the wiki template for specific awards and medal criteria with static (unchangeable) links. We refer to these pages as standard pages.

If a team wants to be evaluated for a medal or special prize, they will need to document their achievements related to this medal or special prizel on these standard pages. For example, if a team wishes to compete for the Best Plant Synthetic Biology special prize, they need to complete the **Plant Page** on:
http://2018.igem.org/Team:Example2/Plant

The judges are directed to these pages from static links within the judging ballot. Teams should put all the information needed to convince judges on the award page and have supplementary material on separate pages, as you would with supplementary data in a publication.

What does this mean?

Regardless of how teams style their wikis, they will need to preserve designated URLs in order to be evaluated for the awards listed on page 42 and page 46. Web design packages that create their own dynamic links will not work with our evaluation system. Judges should also look for content hosted on external sites as teams who do this are ineligible for the wiki award and may be ineligible for any medal.

So where are the links?

Team wikis will include all of the necessary pages by default. You can refer to the list of pages for medals on page 42 and for special prizes on page 46. All content (except part pages on the Registry) should be contained in the official team name space.

For example: **http://2018.igem.org/Team:Example2**

CHAPTER 2

EXCELLENCE IN IGEM

Finalist Case Studies

What are the characteristics of the very best iGEM projects? What sets them apart?

A team that will win the iGEM Competition not only presents a successful and well-communicated project, but also embodies the goals and values of the iGEM Foundation itself – advancement of synthetic biology, impact, education, accomplishment, use of standard parts, and integration of human practices, to name a few.

A successful iGEM project includes the following components: a wiki, a poster, a presentation at the Jamboree, and, depending on the track, a deliverable to be used by the community (e.g., DNA parts, software, etc). Although great teams demonstrate excellence in all of these components, the very best teams go above and beyond, not only presenting a clear and powerful story, but also connecting their projects to the wider world through careful consideration of their project's consequences. Finally, it is important to note that iGEM is about education; projects should be motivated, researched, and carried out primarily by students. Effective use of available resources is important and encouraged, but careful attention should be paid when the team writes the attribution of each part of their project.

These facets of success are reflected in the "Project" section of the judging ballot, which is the main determinant for choosing finalists:

1. How impressive is this project?

2. How creative is the team's project?

3. Did the project work?

4. How much did the team accomplish (addressed a real world problem, produced functional BioBricks, carried out Human Practices, created a wiki, presentation, poster, etc.)?

5. Is the project likely to have an impact?

6. How well were engineering principles (for example: modularity, prototyping, debugging, standardized measurements, etc.) used?

7. How thoughtful and thorough was the team's consideration of human practices?

8. How much of the work did the team do themselves and how much was done by others?

9. Did the team design a project based on synthetic biology and standard parts?

10. Are the parts' functions and behavior well-documented in the Registry?

The first eight aspects are the key iGEM values that apply to all teams, irrespective of track. The final two aspects are distinct for Standard (parts- based) Tracks and Special (non-parts-based) Tracks. The aspects shown above are for Standard Tracks. Due to significant differences in project design and execution, it is important to note that Special Track teams are not eligible to be finalists or to win the Grand Prize. For more information on Special Tracks and how to judge them, see the relevant sections later in the Handbook (starting on page 93), as well as the chapter on medal requirements (starting on page 37).

Regardless of project or track type, excellent teams do not necessarily need to score highly in every aspect; they create work that impresses the judges. Impressing the judges is what distinguishes winning teams from great teams. Using the rubric, judges can reward the best work according to how impressive the scale and scope of the project is, instead of according to a minimum set of criteria that teams need to meet. Judges evaluate how much teams achieved in a given time, which is not limited to "tick box" criteria that they check off as they complete.

To get a better idea of what judges recognize as exemplary, we will explore four finalists' projects:

Vilnius-Lithuania 2017
http://2017.igem.org/Team:Vilnius-Lithuania

Imperial College 2016
http://2016.igem.org/Team:Imperial_College

Czech Republic 2015
http://2015.igem.org/Team:Czech_Republic

UC Davis 2014
http://2014.igem.org/Team:UC_Davis

Vilnius-Lithuania 2017 NEW

http://2017.igem.org/Team:Vilnius-Lithuania

SynORI – a framework for multi-plasmid systems

The team's project focuses on the idea of a controllable, standardized multi-plasmid framework, which can easily be applied by future teams. Their project was the Grand Prize winner of the undergraduate section in 2017.

Team Vilnius-Lithuania's core idea looked at the balanced expression of multi-plasmid systems, where current negative impacts like plasmid loss, unbalanced replication or incompatibility of co-maintaining plasmids with different types of origins of replication, running out of useable antibiotic resistance genes, and issues with inheritance of the plasmids to daughter cells would be addressed as well as solved within their project.

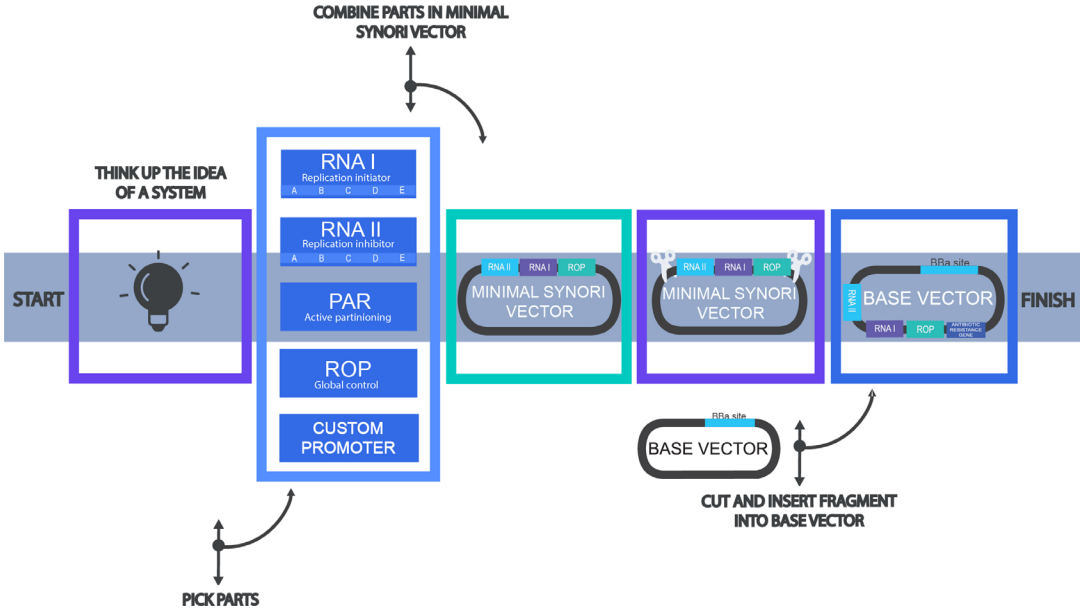
Their solution to these fundamental but complex issues was using synthetic origins of replication (SynORIs) to manage the plasmid copy number (PCN). The newly designed ORIs were coupled with a selection system requiring only one antibiotic resistance for up to five different plasmids per cell and an active partitioning system to ensure plasmid stability during cell division.

The resulting system should be easy adaptable for different scientific problems:

The team based their experiments on extensive literature research. They implemented their own ideas on the previously published information to tackle current issues in plasmid replication making this project creative and novel (**aspect 2**). In addition, as plasmids are extensively used in scientific research, industry, and iGEM itself (BioBricks), the project may likely have an impact in the field (**aspect 5**).

The team members first established a method measuring the plasmid copy number (PCN). Absolute quantitative PCR with specific primers to discriminate between bacterial and plasmid based oris were used. Next, the ColE1 ori was re-engineered in order to gain control over the PCN. ColE1 consists of two antisense RNA molecules: RNA I and RNA II. RNA I is known to inhibit replication as RNA II is seen as the activator of replication. Vilnius-Lithuania marked the RNA I gene and its promoter as their primary target for designing their PCN device. Before starting the wet lab work, the core idea of RNA I reducing the PCN was successfully modeled by an ODE approach.

RNA I and RNA II are two antisense molecules, so the team needed to separate the genes from one another, which was a novel idea and thus had not been done before (**aspect 2**). Subsequently, the team disabled the RNA I promoter.

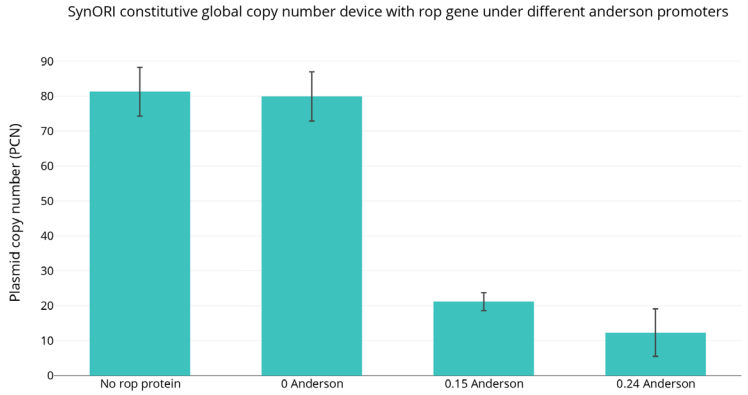


The team's vision is a standardized, easy adaptable system to be used for multi-plasmid system of different purposes.

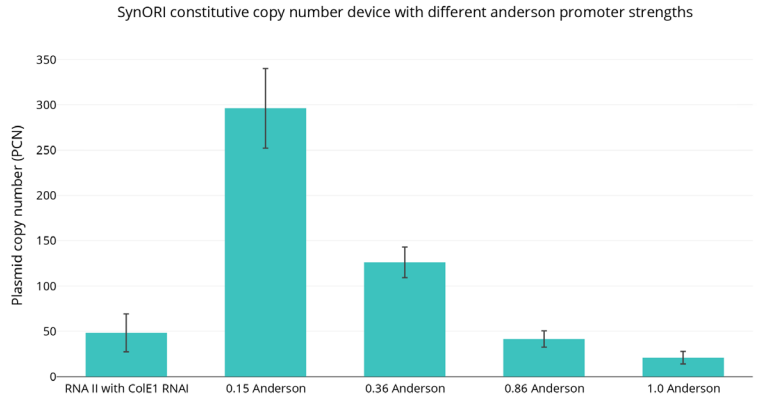
After disabling the promoter sequence they set the RNA I gene under the control of different Anderson promoters as well as a rhamnose promoter. Those constructs were placed next to the RNA II gene. Thus, they were capable of controlling the PCN in a constitutive and inducible manner.

After being able to control the PCN of a plasmid, the team established control over multi-plasmid groups and subsequently global control over all plasmid groups simultaneously. By testing different secondary structures of the RNA I and RNA II in search of the perfect interplay between RNA I and II, the Vilnius-Lithuania team achieved classification of and control over different multiple plasmid groups. Furthermore, they used the secondary RNA structure binding protein called Rop coupled to different Anderson promoters as a global copy number regulator.

Finally, the team needed a selection system to maintain high numbers of different plasmids in their system. Their approach was based on a split antibiotic resistance gene. The two parts of the gene were divided on two plasmids. If both plasmids were maintained in the cell, then the antibiotic resistance would work properly. Both parts of the antibiotic resistance gene were set under the control of dynamic riboregulators, called “toehold” switches. The switch harbored an RBS and a start codon in a linker sequence, which were both sequestered by a secondary RNA structure. By adding the right RNA trigger, the RNA duplex formation was initiated, resulting in the revealing of RBS and linker start codon. With this method, the team demonstrated the ability to maintain up to five plasmids in one cell.

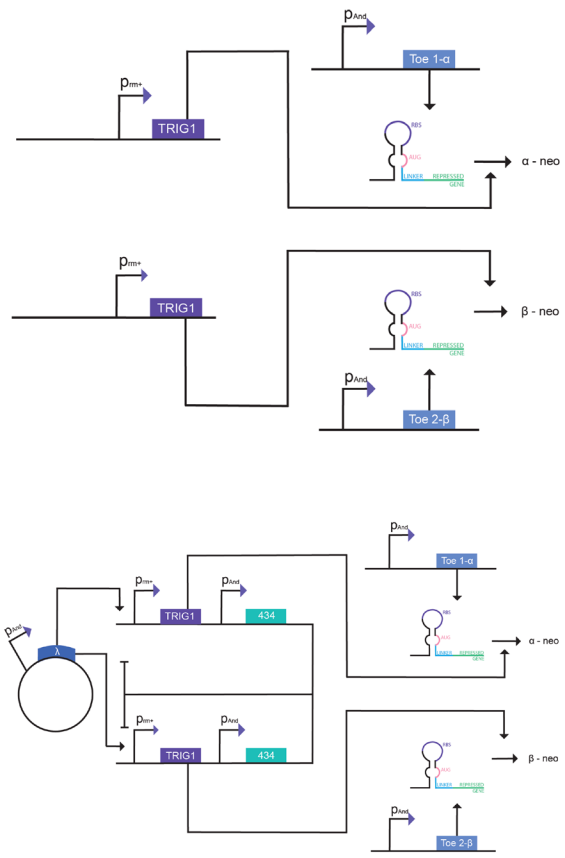


Rop protein is used to control the PCN on a global scale. The strength of the Anderson promoter upstream of the rop gene is directly coupled to the PCN control.



Constitutive control over the PCN by “exchanging” the native RNA I promoter with Anderson promoters of different strength.

The practical work of the Vilnius-Lithuania team impressed the judges as it addressed an important need and aspect of everyday lab work (**aspects 2 and 5**). Furthermore, all subparts of the project were well-engineered and used standardized parts, and the team showed successful execution of their design (**aspects 3, 4, 6, and 9**). The team also took an extensive integrated human practice approach, talking to potential users of their product and stakeholders in the field. Beyond that, they thoughtfully engaged in the educational/public engagement aspects of human practices by developing an Augmented Reality framework for synthetic biology, to be used by teachers in schools. Additionally, they participated in public discussions, engaged in Bioart exhibitions, and discussions about Bioethics (**aspect 7**). Overall, the team's implementation of their initial ideas coupled with their human practice efforts made their work an impressive iGEM project (**aspect 1**).



The selection system for four plasmids (A) and five plasmids (B). The system is built upon a split antibiotic gene under the control of a "toehold" riboswitch.The switch itself is under the control of RNA triggers. The system can be expanded by a transcriptional factor to control the RNA triggers.

Imperial College London 2016

http://2016.igem.org/Team:Imperial_College

Imperial College London was the undergraduate Grand Prize winner of the Giant Jamboree in 2016. The Imperial College London 2016 iGEM team decided to tackle the problem of growing co-cultures in the lab, as different microorganisms exist together in their natural ecosystems. However, this strategy is difficult to do in vitro because each culture requires a different set of growth conditions. Applications of using co-cultures are endless and range from using antibiotic free human therapeutics to preventing pathogenic bacteria from growing on spacecraft.

They wanted to design a genetic circuit that allows ratiometric control of populations in co-culture.

Three components were used:

1. A communication module that utilises quorum sensing to allow the E. coli bacteria population and the other co-bacteria population to detect their own population density

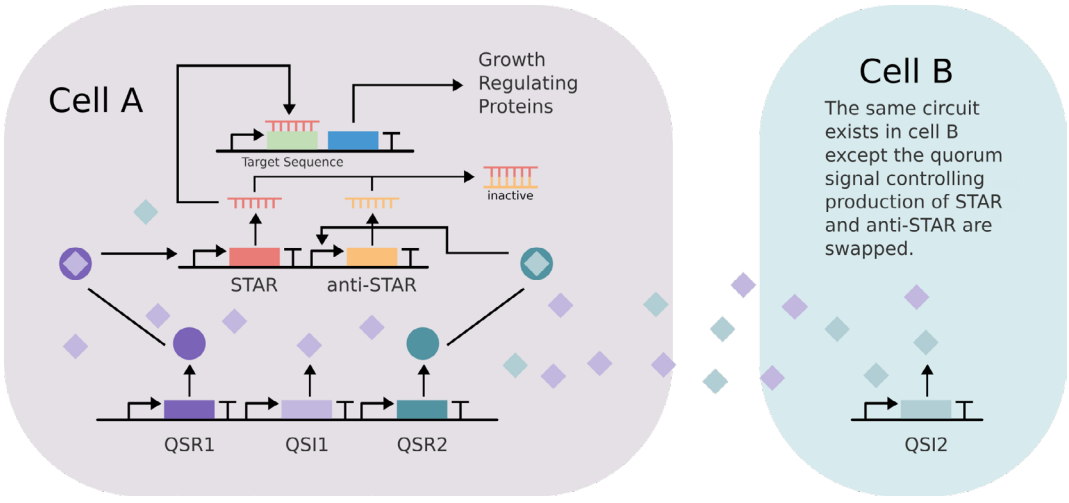
2. The comparator module that links quorum sensing to RNA logic so that the population can compare their own population to the other population cell-line

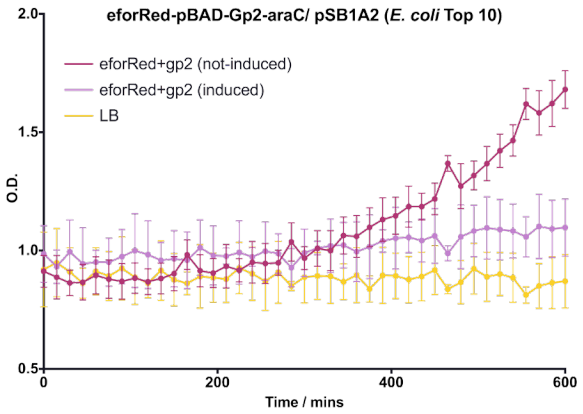
3. A growth regulation module that allows the cell line to respond to the signal from the comparator's module to regulate each other's population growths

These three components make up Genetically Engineered Artificial Ratio (G.E.A.R.) system as shown in the figure at the bottom of the page.

As proof of principle they transformed two cell populations with different chromoproteins. They showed that co-cultures fail because one culture will grow faster than another. In order to show that control of growth could be used to produce a stable co-culture and could maintain its ratio over time, they combined the arabinose-inducible Gp2 construct (growth regulating protein expressed from a phage gene that was used for their G.E.A.R. system) with a construct for the chromoprotein, eforRed.

When arabinose was added, the growth of Gp2 was inhibited. As you can see from the graph on page 29 the efoRed+Gp2 construct showed a decrease in growth rate when induced with arabinose, suggesting that their genetic circuit was a suitable system for controlling the growth of cells.

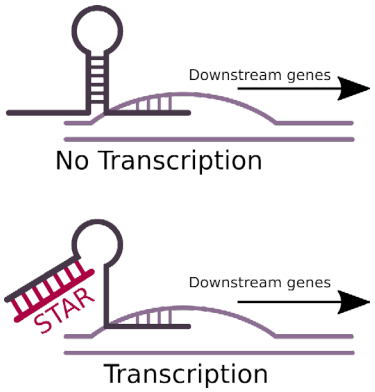




This project was **impressive** (**aspect 1**) especially in their design using **engineering principles** (**aspect 6**) of the co-culture experiments, the amount of work done in characterizing their components and also incorporating mathematical modeling of each module of the G.E.A.R. system. They have shown that they were able to accomplish many of their set tasks (**aspects 3, 4**).

There are many aspects that were **creative** (**aspect 2**) in this project. For example, they were the first iGEM team to introduce a small transcriptional-activating RNA (STAR) that was used for transcriptional regulation in their comparator module. It works by binding to an introduced terminator just upstream of the growth-inhibiting gene interfering with the hairpin structure, thus allowing transcription to be turned on. One of the key advantages of using STAR is it has very tight regulation.

This part won the **Best New Basic Part**:
http://2016.igem.org/Team:Imperial_College/Basic_Part



They were also the first iGEM team to use a tool to integrate social policy and lab research called **Socio-Technical Integration Research protocol (STIR)** (http://2016.igem.org/Team:Imperial_College/Integrated_Practices). This tool can be used by future iGEM teams to provide an initial framework for their projects.

In addition to this **standard part**, they submitted an impressive number of composite parts to the iGEM (http://2016.igem.org/Team:Imperial_College/ Composite_Part) Registry that have been well characterized and documented (**aspects 9, 10**). They also designed a computer software tool called (**Advanced Logging Interface for Culture Experiments** (**A.L.I.C.E.**)) (http://2016.igem.org/Team:Imperial_College/Software) which will be helpful to other iGEM teams when they design their own co-culture experiments.

These parts and tools are readily accessible to the iGEM community and are likely to have an impact on other teams (**aspect 5**).

The judges were very impressed by the **human practices** where the team designed a game that explains co-cultures to the general public that is fun and is clearly understood by anyone and is available as an **App** (http://2016.igem.org/Team:Imperial_Collegez#Game) (**aspect 7**). The team clearly stated in their wiki the attributions and their collaborations (work done by **themselves or others, aspect 8**).

Apart from the impressive data from the wet and dry lab experiments, the team produced a wiki and poster that were both fun and eye-catching with high quality graphics, resulting in their also winning the Best Wiki and Best Poster special prizes.

Czech Republic 2015

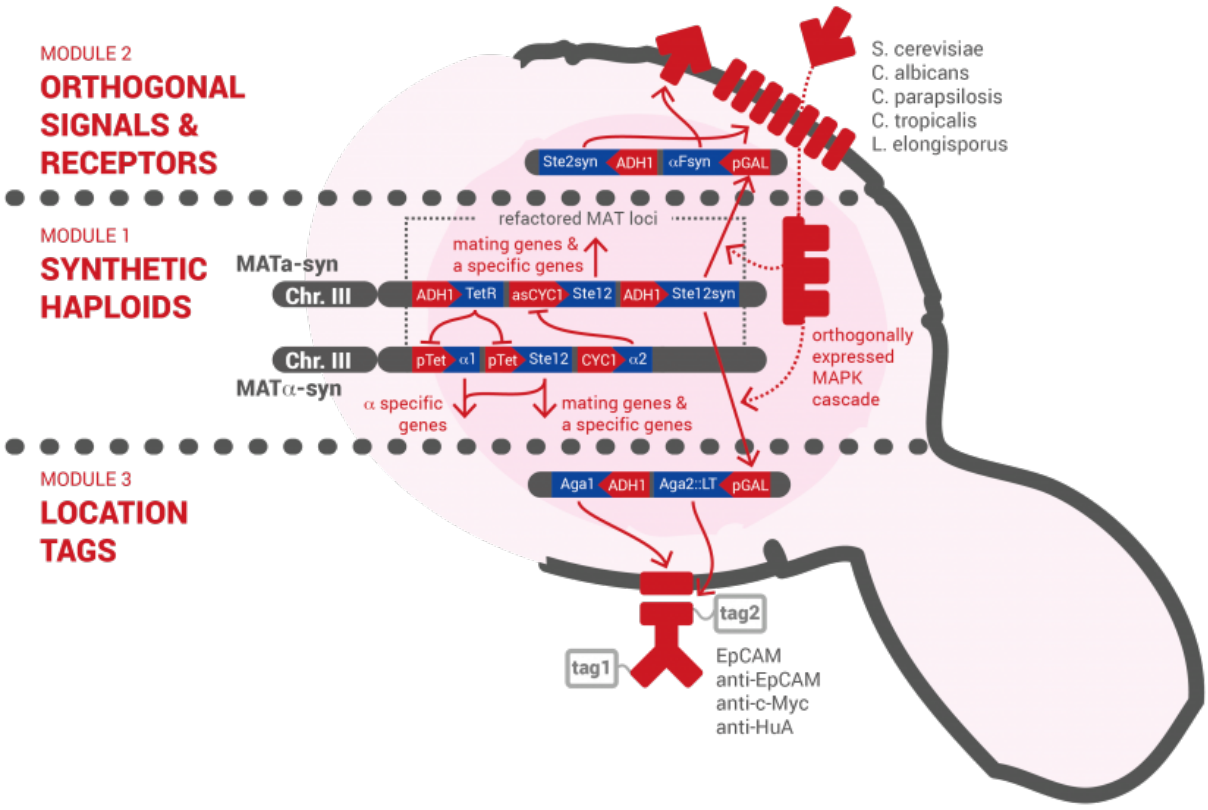
http://2015.igem.org/Team:Czech_Republic

The project of Czech Republic 2015 dealt with the development of a cheap and easy-to-use test to detect the presence of cancer cells that left the primary tumor to migrate into other organs (so called Circulating Tumor Cells, CTCs) in a sample of peripheral blood . Being able to detect CTCs early enough (before they have the chance to form metastases in other organs) would potentially save many lives. The beauty of the project lies in its modularity and in the novelty of the approach. It impressed the judges and was awarded with 1st Runner Up, Undergrad, at the Giant Jamboree in 2015.

The idea at the core of the project was to engineer yeast cells to: a) expose on their surface a single- chain variable fragment (scFv) antibody for the recognition of a specific antigen in the extracellular medium and b) react by forming clumps visible to the naked eye.

The team thought of exploiting the very well studied yeast pheromone response pathway; haploid yeast cells use this MAPK signaling cascade to detect the presence of cells of the opposite mating type – announced by their pheromone – and to respond by arresting the cell cycle, expressing mating-specific genes, and growing a mating protuberance in the direction of the mating partner. The name of the project was IOD band. IOD stands for Input Output Diploids. Yeast diploids arise from natural mating between two haploid cells, a process that the team called “clone-free” assembly.

The following graphic from the team’s wiki shows the main concepts of the project, including its modularity:



A very interesting engineering part of the project consisted in finding ways to keep the mating pathway turned 'on' in diploid cells while not allowing synthetic diploids to undergo further mating. The team's solution was two-fold: 1. They eliminated the natural transcription factor a1, which plays no role in haploid cells but represses expression of mating- specific genes. a1 was replaced by the tetracycline- dependent transcriptional repressor TetR; 2. They substituted the endogenous promoter of the Ste12 transcription factor (that activates mating genes) with a synthetic a-specific promoter which is repressed in diploids. Since Ste12 is essential for mating, it could not be eliminated in haploids as it was done with a1. Thus, a good solution the team found was to repress it only in diploids.

Moreover, they used a synthetic Ste12 protein obtained from another group, which is a hybrid between GAL4 and Ste12. This synthetic transcription factor binds to the GAL4 operator site, but is active only in presence of pheromone (which releases Dig1 and Dig2 from the activation domain of Ste12).

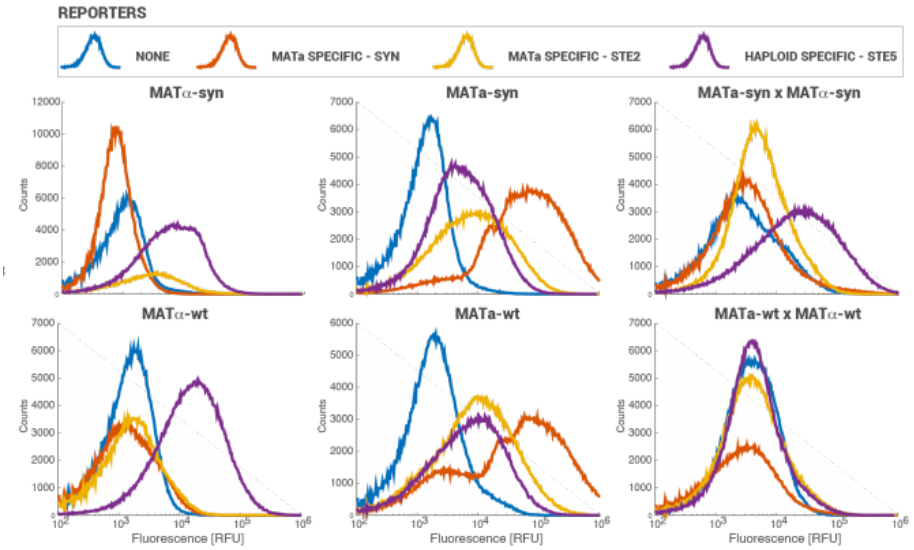
To test the functionality of their engineered haploid and diploid strains, the team conducted a series of experiments. First they checked the ability of the synthetic haploids to mate. Then they checked expression of a GFP reporter gene cloned under various promoters that were active either in haploid (a or alpha) or diploid cells.

Their flow cytometry comparison of the wild type and the synthetic strain support the idea that the strains behave as expected:

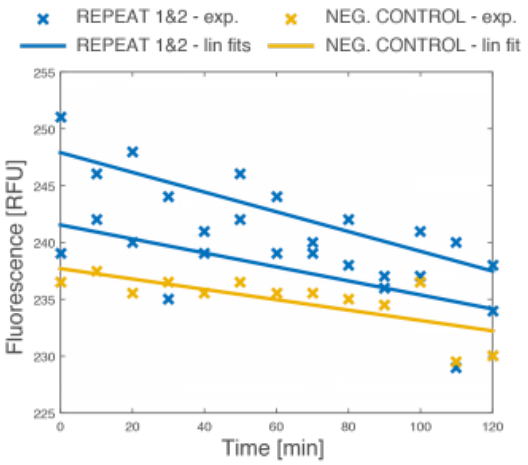
An important step was to prove that scFv antibodies exposed to the surface of the IODs were able to detect the presence of the antigen and form visible clumps. As a proof-of-principle, the team used well-known (non-cancer) proteins and scFv antibodies: biotin, EpCAM, c-Myc, and HuA. The latter was especially selected to carry out a first test with blood that contains this protein (human Antigen A).

The technique to express scFvs on the yeast surface was already published and the team obtained the plasmids to perform yeast display from another laboratory. They could show that the selected proteins were exposed on the surface of their yeast strain by immunofluorescence.

They also showed that blood cells were retained on the yeast strain exposing the scFv antibody against human Antigen A. Finally, they mixed two yeast strains, one displaying anti-EpCAM scFv and another displaying EpCAM itself. The first strain produced wild-type pheromone after induction with copper sulfate. The second carried a reporter GFP gene that was induced by the pheromone produced by the other strain.



As the following picture shows, there was some minor GFP production when the two strains were mixed:



A big merit of the Czech Republic team was to develop a software environment called **CeCe** (**http://2015.igem.org/Team:Czech_Republic/Software**) for modeling cell-cell interactions all the while simulating stochastic chemical reactions in the individual cells. In this simulated environment, cells enter and exit a 2D world through predefined channels of arbitrary shape. Stochastic reactions characterize each cell and they are executed when the cell is in the 2D world. Cells also interact with each other.

This project **impressed** the judges (**aspect 1**), because it is well thought-out, modular, and its various parts are very harmonious. The project has several nice **novel** ideas (**aspect 2**) that were absent from iGEM (for instance, an a-specific tunable promoter).

The team provides evidence that parts of their project **worked** (**aspect 3**) and used several techniques including microfluidics and mathematical modeling/ simulations. Therefore, they **accomplished** some important steps (**aspect 4**) towards this visionary idea of having a cheap and easy-to-use strip test for detecting CTCs.

Throughout their entire project, the team used concepts of engineering (**aspect 6**) and contributed several BioBricks to the Registry. Moreover, their simulation software is likely to have an **impact** (**aspect 5**) even outside of iGEM because other scientists in the community might want to use it.

In addition, among other activities such as a survey on GMOs, the team met with engineers and medical doctors to discuss with them their project and managed to attract engineers to synthetic biology (**aspect 7**). Finally, their presentation was extremely nice and well organized, and their graphics were professional and appealing, which of course always helps impress the judges!

UC DAVIS 2014

http://2014.igem.org/Team:UC_Davis

UC Davis was the 2014 overgraduate section champion. After learning that over 70% of imported olive oils and many US olive oils are rancid, UC Davis chose to develop a method to help ensure consumers receive quality extra virgin olive oil.

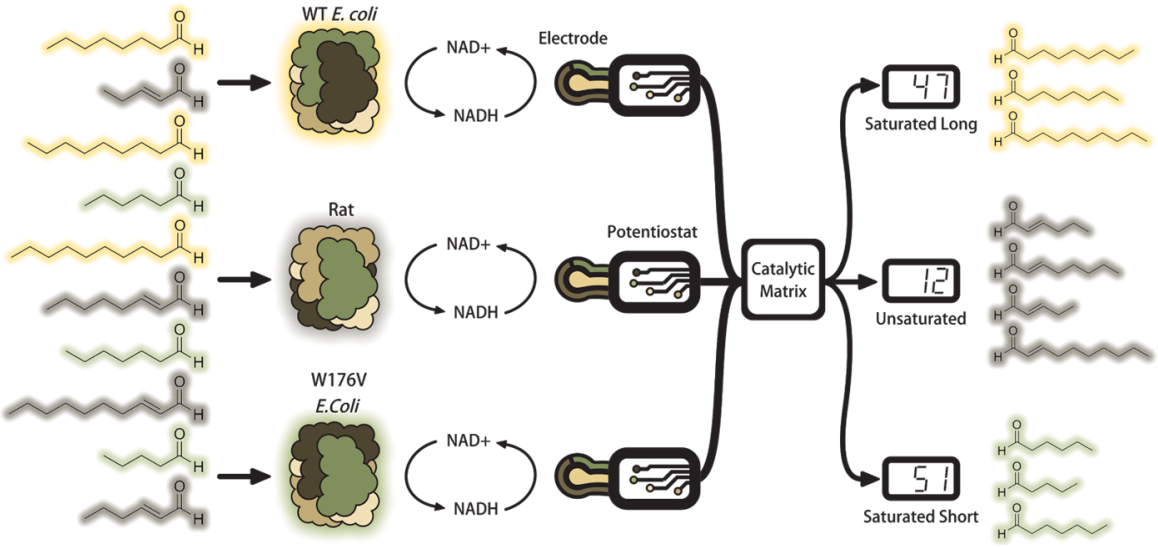
Their "OliView" project consisted of these major components: 1) protein engineering; 2)electrochemistry; 3) potentiostat development and 4) signal processing.

The development of an enzyme-based electrochemical biosensor for the evaluation of rancidity in olive oil is nicely summarized in the "How Did We Do It?" diagram:

Let's look at specific aspects nicely addressed by their project.

How much did the team accomplish (aspect 4)? Did the project work (aspect 3)?

First, they identified NAD+ dependent aldehyde dehydrogenases with unique specificity profiles from online databases and designed 20 mutants of E. coli aldehyde dehydrogenase. They developed a simple spectrophotometric plate assay which measured the concentration of NADH in a solution. Using this assay, they screened 23 aldehyde dehydrogenases against all sixteen aldehyde substrates they previously identified to occur in olive oil.



Average Catalytic Efficiency for Each Enzyme on Each Bin

	Medium, saturated Aldehydes (C5-C7)	Long, saturated Aldehydes (C8-C10)	Unsaturated Aldehydes
WT *E. coli* ALDH	100%	95.30%	8.40%
W176Q Mutant *E. coli* ALDH	98.73%	100%	1.82%
WT Rat ALDH	100%	75.48%	71.01%

hey identified three enzymes with unique specificity profiles.

They needed to develop an electrode system to detect enzyme activity via NADH. To accomplish this part of their project, they acquired, selected, and optimized an electrode setup for the detection of NADH at low concentrations in a complex solution. Additionally, they built and tested a potentiostat to measure enzyme-generated NADH.

After validating that their system could detect enzyme activity, they developed a mathematics and software suite to connect measured aldehyde profiles to the degree of rancidity in a particular olive oil. They tested their working model with nine samples of extra virgin olive oil. They successfully detected two out of three rancid samples (as determined by a more traditional, more expensive method).

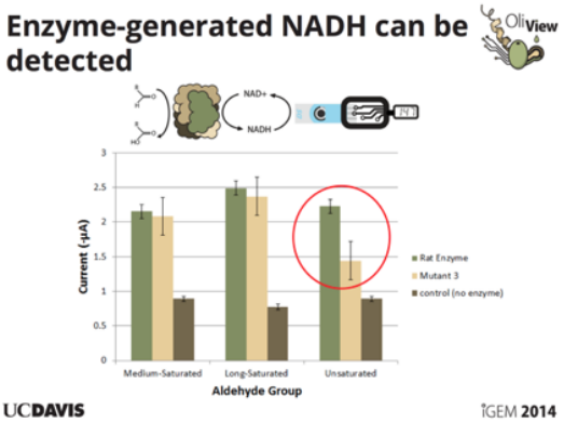
Practical Implications for the Development and Deployment of Engineered Biosensors in Olive Oil Production

Prepared by:
UC Davis iGEM 2014

Prepared for:
2014 International Genetically Engineered Machines (iGEM) Jamboree in satisfaction of Gold Medal Requirements

How thoughtful and thorough was the team's consideration of human practices (aspect 7)?

To satisfy the gold medal requirement, UC Davis conducted an in-depth analysis of how customers and stakeholders in the olive oil industry influenced their project and how their project could possibly impact them.



Throughout the summer, the team met with representatives from the largest producers of extra virgin olive oil in California. They toured production facilities and learned about industrial quality control. Inspired by discussions about producer interest in new analytical devices, they chose to build a new device to detect aldehydes in rancid olive oil.

After participating in several olive oil tastings, they decided to reach out to the community by holding their own olive oil tasting to educate consumers about how rancid olive oil tastes as compared to fresh olive oil. In addition, they attended a public hearing organized by the California Department of Food and Agriculture at the State Capitol to record evidence and testimony presented by olive growers, millers, and the general public on a set of standards proposed by the Olive Oil Commission California (OOCC). Human Practices was deeply integrated with the team's project and substantially addressed broader concerns.

UC Davis won Best Policy & Practices Advance, Overgrad section.

How impressive is this project (aspect 1)?

UC Davis was the Grand Prize Winner of the Overgrad section at the iGEM 2014 Giant Jamboree. The judges were impressed with how the project was designed and executed. The motivation for and potential applications of the project were clearly defined. Engineering principles were professionally incorporated into the project. Additionally, the project was clearly communicated to a wide audience on the team wiki and poster and in the presentation.

CHAPTER 3

MEDALS

Introduction

Summary

- Teams earn medals by meeting specific criteria. There are separate medal requirements for Standard Tracks (includes High School teams) and Special Tracks.
- Teams “compete” against themselves for medals -- they should not be compared to other teams when assessing these criteria
- Many medal criteria can be assessed by following the standard wiki page links in the Judging Ballot. If sufficient information to meet a specific medal criterion or award cannot be found under its corresponding wiki page, you can choose to consider the requirement unmet.
- It is up to the teams to convince the judges they have achieved the requirements and/or criteria.

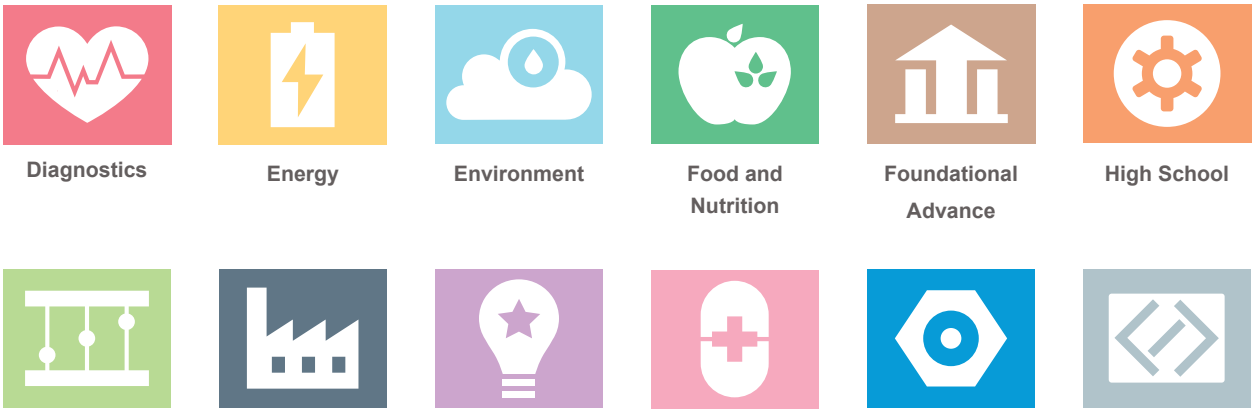
All teams are competing for medals at the Giant Jamboree. The number of medals is not limited and teams are only competing with themselves to meet the criteria. Teams can be awarded no medal, bronze, silver, or gold. For a bronze medal, teams must meet all 4 bronze medal criteria. For a silver medal, teams must meet the 3 silver medal criteria in addition to the 4 bronze medal criteria. For a gold medal, teams must meet at least 2 of the 4 available gold medal criteria in addition to all of the bronze and silver medal criteria.

Medal Criteria for Standard Tracks and Special Tracks

There are two sets of medal criteria, one for Standard Tracks and the other for Special Tracks.

The 2018 medals page **http://2018.igem.org/Judging/Medals** lists the criteria (also given starting on page 38). In short, the main difference between the two sets of criteria is based on the use of BioBricks.

For teams in the Standard Tracks, BioBricks are central to the projects. Teams in the Special Tracks do not necessarily need BioBricks for their projects. (Special Tracks are described in detail starting on page 45).



Special Tracks

All criteria must be met

Standard Tracks *Special Tracks*

1. Registration and Giant Jamboree Attendance

All criteria must be met

Register for iGEM, have a great iGEM season, and attend the Giant Jamboree.

2. Competition Deliverables

Convince the judges that you have completed the following Competition Deliverables from this page: **http://2018.igem.org/Competition/Deliverables**

#1 Wiki
#2 Poster
#3 Presentation
#4 Judging Form

3. Attribution

Convince the judges that you have completed Competition Deliverable **#5 Attributions** from this page: **http://2018.igem.org/Competition/Deliverables**

Please note: This requirement is not about citing literature references. Attributions is about describing what work your team did and what other people did for your project.

4. Characterization

Do one of these two options:

(1) Successfully complete the **Interlab Measurement Study** (**http://2018.igem.org/Measurement/InterLab**). This means you have met all requirements of the InterLab Measurement Study, including acceptance of data.

or

(2) Convince the judges that you have added new, high quality experimental characterization data to an existing BioBrick Part (Basic or Composite, must be **RFC10** (**http://parts.igem.org/Help:Standards/Assembly/RFC10**) compatible) from the Registry.

Clearly document the experimental characterization on the Part's Main Page on the Registry see this page for instructions: (**http://parts.igem.org/Help:Contributions**). The part that you are characterizing must NOT be from a 2018 part number range. Sample submission is not required.

4. Contribution

Document on your team wiki at least one new substantial contribution to the iGEM community that showcases a project related to BioBricks. This contribution should be central to your project and equivalent in difficulty to making and submitting a BioBrick Part.

All Bronze criteria must be met, plus all Silver criteria below must be met

Standard Tracks

1. Validated Part

Convince the judges that at least one new BioBrick Part (Basic or Composite, must be **RFC10** - http://parts.igem.org/Help:Standards/Assembly/RFC10 compatible) of your own design that is related to your project works as expected. Clearly document the experimental characterization on the Part's Main Page on the Registry see this page for details: (http://parts.igem.org/Help:Document_Parts).

You must submit a sample of this new part to the Registry (following (**Registry submission requirements**) - (http://parts.igem.org/DNA_Submission#Submission_Requirements).

Teams must follow all of the DNA Submission Requirements and Shipping Guideline: http://parts.igem.org/DNA_Submission to qualify for medals. Failure to follow these guidelines will result in a rejected shipment or sample, which may prevent your team from winning medals and awards.

Special Tracks

1. Validated Contribution

Convince the judges that something you created (art & design, hardware, software, etc.) performs its intended function. Provide thorough documentation of this validation on your team wiki.

2. Collaboration

Convince the judges you have significantly worked with one (or more) currently registered 2018 iGEM team(s) in a meaningful way. For example, mentor a team (or be mentored by a team), characterize a part, troubleshoot a project, host a meetup, model/simulate a system, or validate a software/hardware solution to a synthetic biology problem.

Document your collaboration in detail on your wiki. Judges will look at your collaborator's wiki to see what they say about your interaction. Simply filling out a survey for a team is not enough to demonstrate a significant interaction.

3. Human Practices

Convince the judges you have thought carefully and creatively about whether your work is responsible and good for the world. Document on your team wiki how you have investigated these issues and engaged with your relevant communities, why you chose this approach, and what you have learned. Please note that surveys will not fulfill this criteria unless you follow scientifically valid methods.

See the **Human Practices Hub** (http://2018.igem.org/Human_Practices) for more information and examples of previous teams' exemplary work.

All Bronze and Silver criteria must be met, plus at least two (2) Gold criteria below must be met

Standard Tracks *Special Tracks*

1. Integrated Human Practices

Expand on your silver medal activity by demonstrating how you have integrated the investigated issues into the design and/or execution of your project.

See the **Human Practices Hub** (http://2018.igem.org/Human_Practices) for information and examples of previous teams' comprehensive and innovative activities.

2. Improve a previous part

Convince the judges that you have created a new BioBrick Part (must be **RFC10** - http://parts.igem.org/Help:Standards/Assembly/RFC10 compatible) that has a functional improvement upon an existing BioBrick Part (must be **RFC10** - http://parts.igem.org/Help:Standards/Assembly/RFC10 compatible). The sequences of the new and existing parts must be different. You must perform experiments with both parts to demonstrate this improvement.

Clearly document the experimental characterization on the Part's Main Page on the Registry for both the existing and new parts see this page: http://parts.igem.org/Help:Document_Parts for details. The Main Pages of each part's Registry entry must link to each other. The existing part must NOT be from your 2018 part number range and must be different from the part you used in Bronze #4. The new part must be different from the new part documented for Silver #1. Submit a sample of the new part to the iGEM Parts Registry (following the **Registry submission requirements** (http://parts.igem.org/DNA_Submission#Submission_Requirements).

2. Improve a previous project

Improve the function of an existing iGEM project (that your current team did not originally create) and document your achievement on your wiki.

3. Model your project

Convince the judges that your project's design and/or implementation is based on insight you have gained from modeling. This could be either a new model you develop or the implementation of a model from a previous team. You must thoroughly document your model's contribution to your project on your team's wiki, including assumptions, relevant data, model results, and a clear explanation of your model that anyone can understand.

The model should impact your project design in a meaningful way. Modeling may include, but is not limited to, deterministic, exploratory, molecular dynamic, and stochastic models. Teams may also explore the physical modeling of a single component within a system or utilize mathematical modeling for predicting function of a more complex device.

4. Demonstrate your work

Convince the judges that your engineered system works.

Your engineered system has to work under realistic conditions. Your system must comply with all rules and regulations approved by the iGEM Safety Committee: http://2018.igem.org/Safety. Your system can derive from or make functional a previous iGEM project by your team or by another team.
For multi-component projects, the judges may consider the function of individual components.

Updates to Medal Criteria NEW

Parts used for the fulfillment of the medal criteria Bronze #4, Silver #1 and Gold #2

Teams may choose to characterize an existing part for Bronze #4 and may choose to improve a part for Gold #2. Teams must submit a new part for Silver #1. If a team chooses to fulfill all three of these Part-based criteria, then the team must use three different BioBricks to achieve all three medal criteria.

The characterized BioBrick Part for Bronze #4 must NOT be from the 2018 parts number range. It cannot be a BioBrick made from the team in 2018, but must be an already existing one from the Registry.

The BioBrick Parts to be used for the Silver #1 and Gold #2 need to be new BioBricks, submitted by the team in 2018. Please be aware that the BioBrick Parts must be different for both criteria. Silver #1 needs a newly created and characterized BioBrick part central to the team's project. Gold #1 needs an improvement of an already existing BioBrick Part. By improvement the team will change the DNA sequence of the BioBrick Part. Therefore, the team must submit this new improved part to the Parts Registry, resulting in a new BioBrick Part with a 2018 part number.

Gold Medal Criterion 2

Convince the judges that you have created a new BioBrick Part (must be RFC10 compatible) that has a functional improvement upon an existing BioBrick Part (must be RFC10 compatible). The sequences of the new and existing parts must be different. You must perform experiments with both parts to demonstrate this improvement.

This criterion requires a new BioBrick Part from the team that is a functional improvement of an already existing BioBrick Part from the Registry. The team must also submit a sample of this new BioBrick Part to the Registry. The sequences of the new and existing part must be different. Both parts must also be RFC10 compatible, so please note that a team who changes the sequence of a non-RFC10 part to now be RFC10 compatible has not fulfilled this criteria.

Bronze Medal Criterion 4

Do one of these two options:

(1) Successfully complete the InterLab Measurement Study

or

(2) Convince the judges that you have added new, high quality experimental characterization data to an existing BioBrick Part (Basic or Composite, must be RFC10 compatible) from the Registry.

For (1), the change for 2018 is the inclusion of the terms "successfully complete". Successful completion of the InterLab means the team followed the InterLab protocol, edited their InterLab wiki page, submitted their data on time, and filled out the four online forms on time. The data and forms are reviewed by the Measurement Committee prior to the Giant Jamboree. On the judging ballot, there is a box that will inform you of the team's status. If the InterLab Participation says "Complete" and InterLab Data says "Accepted", the team has fulfilled this criteria and the text will be in green. There is nothing more that you need to do as a judge to evaluate this criteria.

For (2), the changes for 2018 are defining that the BioBrick Part must be RFC10 compatible and specifying that the team must add experimental characterization data. It was unclear to teams previously if any part in the Registry meant it was a BioBrick, so this was updated to clarify that a BioBrick Part by definition must be RFC10 compatible. For the second change, previously we told teams to improve the characterization of a part but now we specify this must include experimental data

Standard Pages for Medals

Below are standard links to the team “Example2” template pages for the medal requirements. For team pages, please replace “Example2” with the team name to find the page on the wiki, or navigate to that page using the menu in the team namespace. Standard Track and Special Track teams must complete these wiki pages to qualify to be evaluated for a medal.

Bronze

All criteria must be met

Bronze #1
No standard wiki page required.

Bronze #2 (Deliverables)
No standard wiki page required.

Bronze #3 (Attribution)
http://2018.igem.org/Team:Example2/Attributions

Bronze #4 (Characterization - for Standard Tracks)
(1) Successful Completion of the InterLab:
http://2018.igem.org/Team:Example2/InterLab
or
(2) Characterizing an Existing Part:

No standard wiki page required.

Bronze #4 (Contribution - for Special Tracks)
No standard wiki page required.

Silver

All criteria must be met

Silver #1 (Validated Part / Validated Contribution):
No standard wiki page required.

Silver #2 (Collaboration)
http://2018.igem. org/Team:Example2/Collaborations

Silver #3 (Human Practices Silver)
http://2018.igem.org/Team:Example2/Human_Practices

Gold

At least **two (2)** criteria must be met:

Gold #1 (Integrated Human Practices):
http://2018.igem.org/Team:Example2/Human_Practices

Gold #2 (Improving a previous part or iGEM project)
http://2018.igem.org/Team:Example2/Improve

Gold #3 (Model your project)
http://2018.igem.org/Team:Example2/Model

Gold #4 (Demonstrate your work)
http://2018.igem.org/Team:Example2/Demonstrate

CHAPTER 4

SPECIAL PRIZES

Introduction

Special prizes are awarded to teams in iGEM who excel in specific areas of the competition. All Standard Track teams are eligible for special prizes and they will be distributed by section (ex: Undergraduate, Overgraduate, and / or High School). Special Track teams are not eligible for the corresponding special prize; for 2018, this means that the Software Track teams are not eligible for the software tool special prize.

Undergraduate, Overgraduate, and High School sections will each receive each type of prize, provided that:

1. **More than 10 teams are competing for the prize**
2. **The work is scored high enough to warrant distributing the award by the judges**
3. **Enough judges vote for the special prize in question**

All information regarding special prize eligibility should be found on the appropriate standard wiki page as described on page 46. If the information is not found there, then a team will be considered ineligible for that prize.

The iGEM 2018 Executive Judging Committee hopes to award the following special prizes, conditional on the accomplishments presented by the teams:

1. **Best Integrated Human Practices**
2. **Best Education and Public Engagement**
3. **Best Model**
4. **Best Measurement** *(formerly Best Innovation in Measurement)*
5. **Best Supporting Entrepreneurship**
6. **Best Product Design** *(formerly Best Applied Design)*
7. **Best Software Tool**
8. **Best Hardware**
9. **Best Plant Synthetic Biology** *(formerly Best Advancement in Plant Synthetic Biology)*
10. **Best New Basic Part**
11. **Best New Composite Part**
12. **Best Part Collection**
13. **Best Wiki**
14. **Best Presentation**
15. **Best Poster**

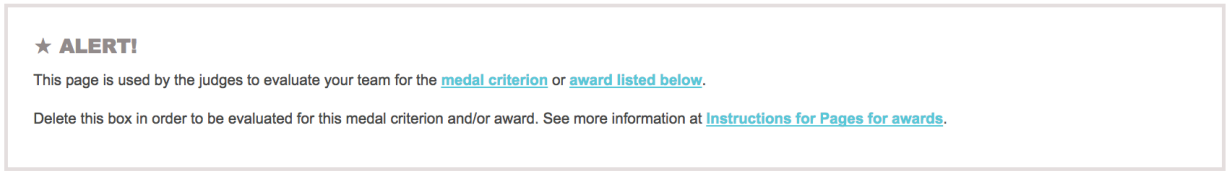
For most special prizes, teams must also provide a 150 word description of what they accomplished on their Judging Form in order to be evaluated for that prize. Exceptions to this requirement are the Best Wiki, Best Presentation, and Best Poster special prizes. These three special prizes do not require teams to provide a 150 word description to be eligible for the award.

Standard Pages for Special Prizes

Teams need to edit the following standard pages to compete for the specified award.

Integrated Human Practices	http://2018.igem.org/Team:Example2/Human_Practices
Education and Public Engagement	http://2018.igem.org/Team:Example2/Public_Engagement
Model	http://2018.igem.org/Team:Example2/Model
Measurement	http://2018.igem.org/Team:Example2/Measurement
Supporting Entrepreneurship	http://2018.igem.org/Team:Example2/Entrepreneurship
Product Design	http://2018.igem.org/Team:Example2/Design
Software Tool	http://2018.igem.org/Team:Example2/Software
Hardware	http://2018.igem.org/Team:Example2/Hardware
Plant Synthetic Biology	http://2018.igem.org/Team:Example2/Plant

The following wiki code appears on all evaluated pages. Teams need to remove it to let the system know they are competing for an award.



Special Prizes and Awards with no required standard page

- **Best Basic Part**
- **Best Composite Part**
- **Best Part Collection**
- **Best Wiki**
- **Best Presentation**
- **Best Poster**
- **Track Awards (based on total body of work, not any specific page)**

Integrated Human Practices

Summary

- Recognizes exceptional work based on the gold medal Integrated Human Practices criteria (see "On Human Practices" on page 17).
- Team should show how they have carefully and creatively considered whether their project is responsible and good for the world and that that they have **reflected and acted** upon these considerations (that are complex and often don't have any single or simple solution).
- Teams should consider both how their project affects the world and how the world influences their project. (e.g., how does stakeholder feedback guide their work throughout the competition?)
- Teams should document a thoughtful approach to exploring these questions and how their project purpose, design and execution changed as a result. The idea of ***why*** their project is important and how it should be executed should be developed through these activities.

The Integrated Human Practices prize is evaluated on the following aspects:

1. **Was their work integrated into their project?**
2. **Does the work serve as an inspiring example to other teams?**
3. **Is the work documented in a way that other teams can build upon?**
4. **Was the work thoughtful in its implementation?**

In this prize, we want to see how projects have evolved based on Human Practices efforts. Teams should convince you that their project reflect iGEM's **values** (http://igem.org/Values), public interests, and should serve as a model for others. We want to see the methods and/or process and results of HP work clearly presented in their wiki, poster, and presentation. Teams should explain the context and rationale for their approach and reference prior work inside and outside iGEM that informed their approach.

Let's explore a few examples of exceptional integrated human practices work from previous years:

Heidelberg 2017 http://2017.igem.org/Team:Heidelberg

The Heidelberg 2017 team developed a directed evolution engineering paradigm as a "Foundational Advance" for synthetic biology and explained how this method might be controversial (**aspect 4**). Beyond merely discussing human practices with diverse experts and the public, they integrated consideration of potential harms and benefits into the evolution toolkit itself (**aspect 1**). The team built and documented (**aspect 3**) a researcher self-questionnaire to encourage responsible use, as well as a web application (SafetyNet) that scans for dangerous sequences.

Purdue 2017

http://2017.igem.org/Team:Purdue/HP/Gold_Integrated

The Purdue 2017 team employed a survey study in an inspiring way (**aspect 2**). They ensured their method was sociologically legitimate by working with experts in survey design and obtaining prior approval from their Institutional Review Board. These methods were well-documented (**aspect 3**), while the results were used to re-envision the intended beneficiaries of the project (**aspect 1**).

HSiTaiwan 2016

http://2016.igem.org/Team:HSiTAIWAN/HumanPractice

The HSiTaiwan 2016 team tackled a locally relevant problem (**aspect 2**) of toxins in traditional Chinese medicines. They spoke with government regulators and manufacturers of Chinese medicine and analyzed government-conducted national health interview surveys to better understand current Chinese medicine use and toxin management practices. Applying these insights to their project (**aspect 1**), the team designed a biosensor to detect the presence of toxins.

Education and Public Engagement

Summary

• Recognizes exceptional efforts to include more people in guiding work in synthetic biology by providing new tools, knowledge, and opportunities.

• Teams should show how their activities establish a *two-way dialogue* with new communities about public values and the science behind synthetic biology.

• Activities do not have to be directly related to the team's project (as is expected for the Integrated Human Practices medal and prize requirements), but may look at wider issues related to iGEM or synthetic biology.

• Teams should **not** "proselytize" or "market" iGEM and synthetic biology by telling the community that synthetic biology is great and will "save the world".

The Education and Public Engagement prize is evaluated on the following aspects:

1. How well did the work establish a dialogue and establish significant educational materials/ programs?

2. Does the work serve as an inspiring example to other teams?

3. Is the work documented in a way that other teams can build upon?

4. Was the work thoughtful in its implementation?

Teams should demonstrate that a conversation was established and describe what each party learned, and how that was determined. We want to see that team's efforts reflect **iGEM's values** (http://igem.org/Values), public interests, and should serve as a model for others. Teams should clearly communicate the methods/ process and results of their work in their wiki, poster and presentation. Teams should explain the context and rationale for their approach and reference prior work inside and outside iGEM that informed their approach.

Let's explore a few examples of exceptional Education and Public Engagement from previous years:

Georgia State 2017

http://2017.igem.org/Team:Georgia_State

The Georgia State 2017 team interacted with hearing impaired students and professionals, seeking greater understanding of how such students experience the laboratory. The team used these lessons to change their lab practice (**aspect 1**), exploring and implementing protocols to make the lab more accessible to all students. These efforts included developing **new sign language** (http://2017.igem.org/Team:Georgia_State/HP/ASL) for the hearing impaired to discuss synthetic biology. They were awarded the Chairman's Award, delivered each year to a team that best exemplifies iGEM values (**aspect 2**).

William and Mary 2015

http://2015.igem.org/Team:William_and_Mary/Practices

The William and Mary 2015 team developed educational activities based on feedback from public workshops they held in order to understand concerns and hopes for synthetic biology (**aspect 1**). They developed 24 activities into an educational booklet with procedures, background information, materials and costs, critical learning questions, and learning goals. The activities were designed to be low-cost and based on materials accessible to teachers, suitable for instructors with limited biology background, and adaptable to any age or educational background (**aspect 3**).

Purdue 2013 and Purdue 2012

http://2013.igem.org/Team:Purdue/Human_Practices/Biomaker_bench
http://2012.igem.org/Team:Purdue/Biomaker_Bench

The Purdue 2013 and Purdue 2012 teams created a community lab (including seeking non-profit status) and a biotech badge for the Girl Scouts of America (**aspects 1 and 3**). The latter activity was done in response to a STEM report released by the Girl Scouts of America. This effort demonstrates how a team used outreach to address a gap that another community identified (**aspect 2**).

Model

Summary

- A model is a representation of a project (or part of a project) that should in some way contribute to project design or understanding.
- Excellent models will have well-documented development. This means that you should be able to understand:
    - What kind of modeling is being done and what information it will provide
    - What assumptions were made and why
    - What kind of data was used to build/assess the model
    - How the model results affected the project design and development

Many (but not all) teams will construct models to aid in the design, understanding, and implementation of their work. Often these are models associated with gene expression and protein function, but teams have also modeled cell behavior, and the behavior of systems or processes of which their engineered devices play a part.

In general, there is an emphasis on models that inform the design of parts or devices, based on real data, using modeling methods likely to be of use in the community. In the iGEM rubric, there are four aspects for model assessment:

1. **How impressive is the modeling?**
2. **Did the model help the team understand a part, device, or system?**
3. **Did the team use measurements of a part, device, or system to develop the model?**
4. **Does the modeling approach provide a good example for others?**

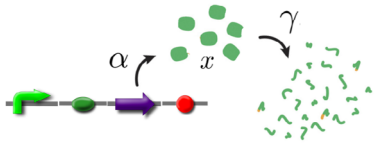
Let's look at some examples for modeling in iGEM.

William and Mary

http://2017.igem.org/Team:William_and_Mary

William and Mary were the 1st runner-up in the Undergraduate section in 2017, largely due to their impressive integration of experimental and modeling work.

Their project focused on creating systems for tunable and dynamic protein expression via the design of protein degradation tags:



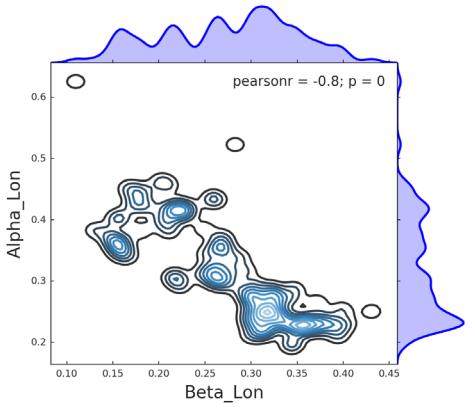
$$\frac{dx}{dt} = \alpha - \gamma x$$

For their modeling, they first put together an ordinary differential equation (ODE) model, a common technique used by many teams. However, since little had been previously done to describe this type of system, this model was relatively novel. Furthermore, accurate parameters estimates for the ODE model were not necessarily available in the literature.

Thus, to predict the values of their model parameters, the team performed a rigorous Bayesian Parameter Estimation with Markov Chain Monte Carlo. This method integrated experimental data they had themselves collected (**aspect 3**).

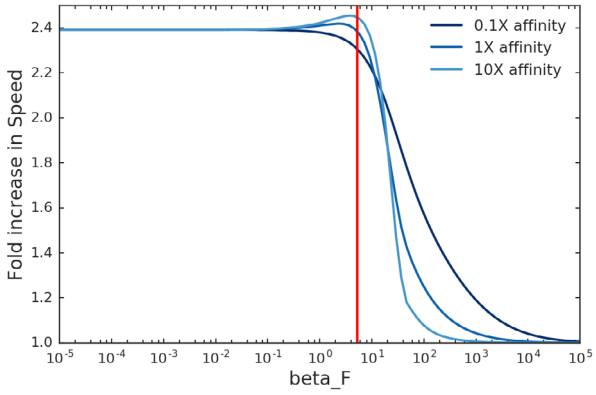
They performed and documented several iterations of their model, showing their progression towards increased reliability and accuracy. In terms of the rubric, the methods and process are impressive (**aspect 1**) due to their novelty and relative challenge. Next, the model definitively helped the team understand their system (**aspect 2**), not only using their specific parts, but to predict how it might behave in other contexts.

For example, they found that the values of two parameters (Alpha_Lon and Beta_Lon) are tightly correlated and can only possess certain values in order to work together:



Next, using their model estimates, they further used their model to predict their experimental system's behavior.

For example, they found that using different protein degradation tags (pdts) did not affect the location of system saturation, but instead affects the rate at which saturation is achieved (i.e., whether the transition is sharp or gradual):



William and Mary further used their model to make several other useful predictions about the behavior of their system and what parameters would be most important to other teams when utilizing their parts

Overall, their wiki describes their methods relatively clearly without getting too much into the details, and the methods their use are appropriate. Thus, their model also provides a good example to others (**aspect 4**).

Colombia Uniandes 2013

http://2013.igem.org/Team:Colombia_Uniandes

Let's consider a few examples. Analysis of gene expression using systems of ordinary differential equations is not unusual in iGEM. Stochastic modeling of the same equations is less common, though by no means rare. **Colombia Uniandes 2013** (**http://2013.igem.org/Team:Colombia_Uniandes**) used both methods to create their model.

While their approach was not unique, they distinguished themselves by careful consideration and research of their model parameters - citing each and lending credence to the veracity of their model. (In iGEM, as in life, one encounters many models composed almost entirely of educated guesses masquerading as parameters.) This approach provides a good example for others (**aspect 4**)

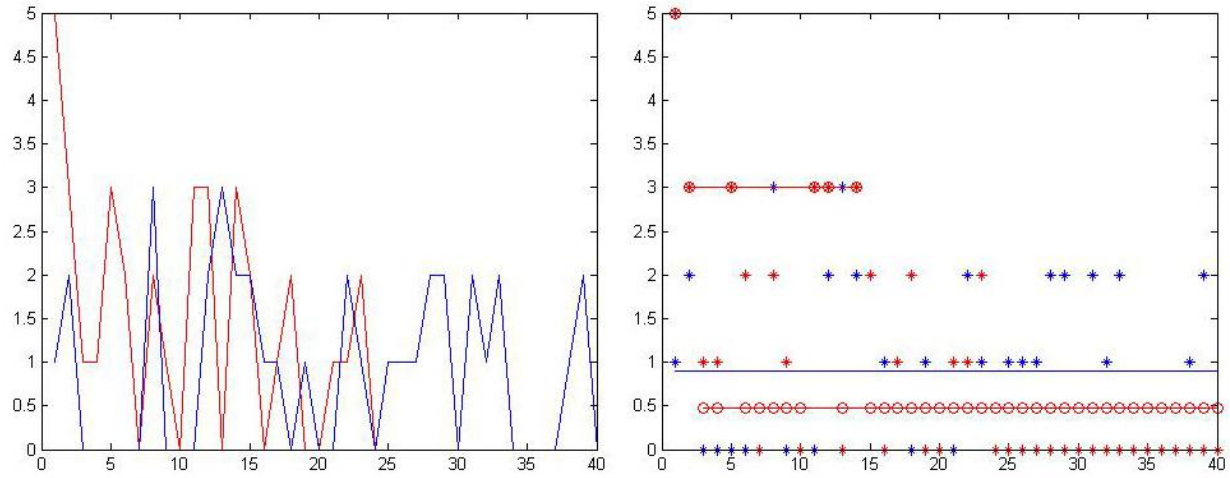
Parameter	Value Deterministic	Units Deterministic	Value Stochastic	Units Stochastic
Diffusion rate of Nickel	**0.5034**	1/min	**0.5034**	1/min
Dynamic constant for the entrance of nickel to the cell	**4.63E-05**	nM (nick)/(nM (HoxN)*min)	**4.63E-05**	molec (nick)/(molec (HoxN)*min)
Porine maximum expression rate	**0.166**	nM/ min	**1.00E-01**	molec/min
Association constant for DNA-RcnR complex	**276**	nM	**1.66E+02**	molec
Association constant of RcnR-Ni	**21-29**	nM	**1.51E+01**	molec
Repressor basal production rate	**0.1**	nM/min	**6.02E-02**	molec/min
Repressor destruction rate	**1/1200**	1/min	**8.33E-04**	1/min
Rate constant for the formation of the tetramer	**0.82**		**8.20E-01**	
Tetramer destruction rate	**1/1200**	1/min	**8.33E-04**	1/min
Cooperation	**1.5-4**	N/A	**1.5-4**	N/A
Porine basal production rate	**0.031**	nM/min	**1.87E-02**	molec/min
Porine destruction rate	**1/1200**	1/min	**8.33E-04**	1/min

Table 1. Parameters of the Deterministic and Stochastic Simulation

OUC-China 2013

http://2013.igem.org/Team:OUC-China

Team **OUC-China 2013** (**http://2013.igem.org/Team:OUC-China**) performed a simulation of the behavior of bacteria with an artificial magnetic organelle in a magnetic field. Their physical model was novel, and noteworthy for its direct comparison to real data from their experiments in a microfluidic device (**aspects 1** and **3**). The model and the data were also used to generate a general equation for magnetobacteria behavior in a magnetic field (see graphs).



KU Leuven 2013

http://2013.igem.org/Team:KU_Leuven

KU Leuven 2013(http://2013.igem.org/Team:KU_Leuven) used their model not only to describe what was happening on the order of a single cell, but also on the order of a colony - influencing their design and probing the robustness of their oscillator. Perhaps more impressively, they also considered the functionality of their devices in the crop farming environment that they were designed for.

This model was used to determine the efficacy of their device and to better evaluate its potential impact (**aspect 2**).

Let's consider the rubric specifically as it relates to this team's model.

KU Leuven performed **flux balance analysis**: (http://2013.igem.org/Team:KU_Leuven/Project/Glucosemodel/MeS/Modelling-FBA) solved for a system of **ordinary differential equations (ODEs):** (http://2013.igem.org/Team:KU_Leuven/Project/Oscillator/Modelling) searching through a reasonably broad parameter space, and considered **physical convection:** (http://2013.igem.org/Team:KU_Leuven/Project/Modelling/Ecosystem_Level) of their pheromone product in a farming environment. They applied a wide variety of techniques to various aspects of their system, and did so very effectively (**aspect 1**).

Their parameters come from the research and, when they are unknown, the team is up front about having estimated them (or searched a reasonable parameter space for them).

Their flux balance analysis was used to determine culture conditions to maximize production, while the ODE was used to consider synchronization of oscillating cells that begin out of phase. The models were not merely constructed; they were used to answer specific questions about the system (**aspect 2**). The practical results of their convection model are less clear, because of the number of unknowns, but the team lets us know that they haven't measurements for many of these parameters, and uses the model instead as a "back of the envelope" exploration of the usability of the system.

The results of their flux balance analysis were compared with experimental data gathered by the team (**aspect 3**). Flux balance analysis and solving a system of ODEs are nothing new to iGEM, but this team did a remarkably thorough job of both, and took care to use these models to answer legitimate questions about their project, rather than throwing up a bunch of disconnected models; modeling for the sake of producing graphs (**aspect 4**).

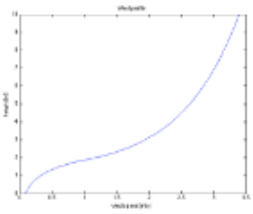


Figure 1 I Wind profile for a crop height of 2 m and a wind speed of 3.39 m/s at a height of 10 m.

Wind speed

Because of friction and obstacles on the earth's surface, wind speed varies with altitude. Generally, the velocity increases with increasing altitude. **A logarithmic wind profile is appropriate for the part above the crops** (Goudriaan, 1977, p. 96). The formula for this profile is

$$u = \frac{u*}{k} \cdot ln\left(\frac{z-d}{z_0}\right)$$

with u representing the velocity. Here d accounts for an upward shift above a vegetative cover. The relation d=0.63 x z_c is suggested, where z_c is the height of the crops. The length z_0 is called the roughness length and is often supposed to be about one tenth of z_c.

Measurement

formerly Innovation in Measurement

Summary

- Teams are rewarded for either performing a stellar set of parts measurements (i.e., part characterization) or for developing a brand new measurement approach.
- Excellent teams will have data that is well documented, repeatable, and useful.

There are a lot of exciting parts in the Registry, but many parts have still not been characterized. The Measurement prize seeks to award efforts to tackle this challenge. Examples of activities that exemplify "Measurement" include (but aren't limited to) designing great measurement approaches for characterizing parts or developing and implementing an efficient method for characterizing thousands of parts.

When judging for the Measurement prize, there are four aspects upon which a team's score is based:

1. **Is the measurement potentially repeatable?**
2. **Is the protocol well described?**
3. **Is it useful to other projects?**
4. **Did the team appropriately use controls to validate the measurement process and calibrate units?**

Most of the documentation for this award should be easy to find on the team's standard wiki page. Other things to think about when evaluating and interacting with a team about this prize could include the idea of comparison to similar approaches. For example:

- Did the team approach the measurement of their part from various angles?
- Did they attempt multiple assays?
- Did they compare their new tool/instrument/assay with an established one?

When teams strive for excellence in measurement, they should also make sure they take the time to understand what came before and to think about what can be done to improve upon existing methods. This information should be clearly stated on their wiki, and the team should convince you that they did due diligence when considering their measurement approach.

Let's look at some measurement examples from previous years.

TUDelft 2017

http://2017.igem.org/Team:TUDelft

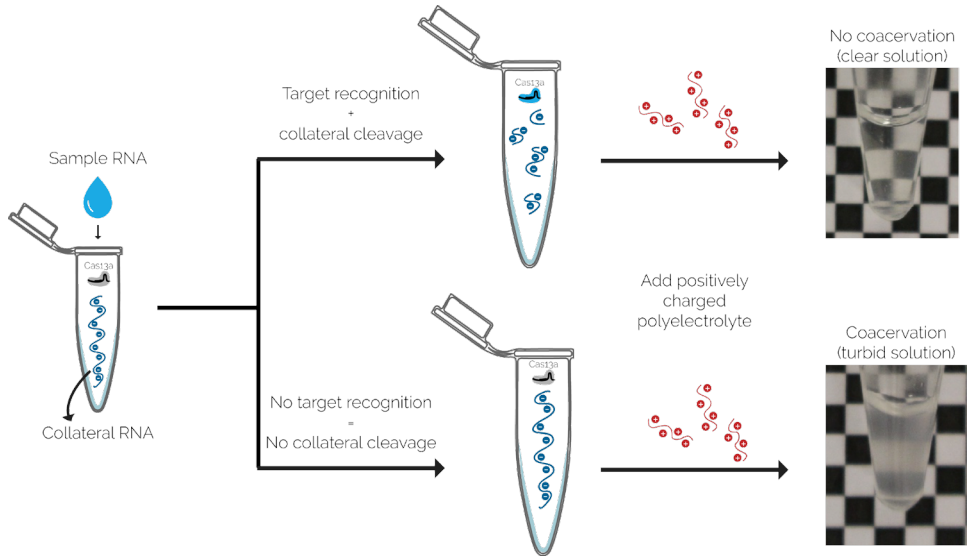
An important aspect of team TUDelft's portable on-site diagnostic assay for antibiotic resistance was to have a simple readout that did not require complex equipment or training. They developed a clever opacity-based readout called CINDY-seq that can be interpreted with the naked eye, and validated its performance under different usage conditions (**aspect 1**).

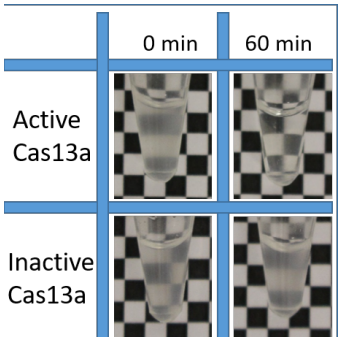
The team was able to demonstrate that their newly invented coacervation method, named Coacervate Inducing Nucleotide Detection of Your Sequence (CINDY Seq), worked well without needing a full lab to analyze the results (**aspect 3**). CINDY Seq allows naked-eye detection of target recognition by Cas13a, exploiting the physical phenomenon called "coacervation".

This is the phenomenon that mutually attracting polymers phase-separate into polymer-rich regions (known as coacervates) and polymer-poor regions if the polymers are long enough and the conditions are right.

TUDelft clearly explained how their measurement approached worked, with excellent documentation and illustrations to help guide their audience (**aspect 2**).

To achieve experimental proof of principle, experiments were designed and separated into three parts: formation and visualization of coacervates, proof of principle with a non-specific RNase and the proof of principle with Cas13a. Their experimental design included two proof of principle experiments, which they tested in full with appropriate controls and showed that each stage worked as expected (**aspects 1, 2, 4**).





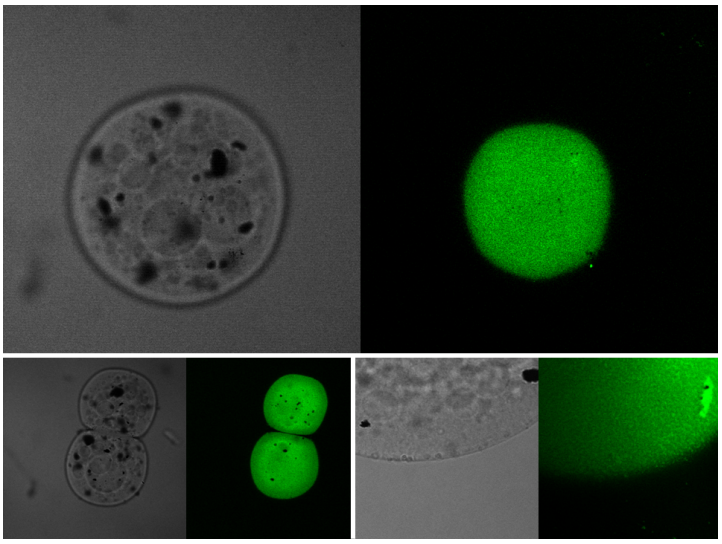
Toulouse 2014

http://2014.igem.org/Team:Toulouse

The Toulouse team developed a new protocol to test the chitin-binding ability of their system using chitin magnetic beads. This test allowed the team to characterize their genetic device that had a chitin-binding domain in it, and they felt confident that it could be used with other BioBricks that display a chitin-binding domain on the surface of a cell (**aspect 3**).

The great advantage of the test is that it allows quantification of the number of cells expressing the chitin-binding domain through the use of a simple serial dilution, plating, and colony counting protocol (**aspects 1 and 2**).

The team also validated that the bacterial cells expressing chitin were attached to the chitin-coated magnetic beads using microscopy (as shown on the left). Through the use of a green fluorochrome (Syto9), they showed the presence of bacteria on the surface of the beads (**aspect 4**).



Supporting Entrepreneurship

Summary

- The Supporting Entrepreneurship special prize is for teams who have explored the entrepreneurial side of synthetic biology.
- Successful teams will have constructed a formal business plan based on customer needs and created a viable product that customers want to use.

The focus of this prize is on ideas taken from lean Launchpad and customer discovery. In other words, teams are encouraged to go speak to potential customers during the initial design phase of their project. The reason for this emphasis on customer discovery is that customer-focused approaches correlate well with business success to a higher degree than teams working solely on business plan and pitch competitions.

The Supporting Entrepreneurship special prize is judged according to the following aspects:

1. **Customer Discovery - Has the team interviewed a representative number of potential customers for the technology and clearly communicated what they learned?**
2. **Based on their interviews, does the team have a clear hypothesis describing their customers' needs?**
3. **Does the team present a convincing case that their product meets the customer's' needs?**
4. **Has the team demonstrated a minimum viable (MVP) product? And does the team have customers to commit (LOI, etc.) to purchasing it / using it?**
5. **Does the team have a viable and understood business model/value proposition to take their company to market?**

Giving teams the opportunity to work on commercialization as part of their project could incentivize some teams to continue their work after the Jamboree. Teams may even consider applying to an incubator or accelerator after iGEM. The aim with this prize is to create the opportunity space and see what happens.

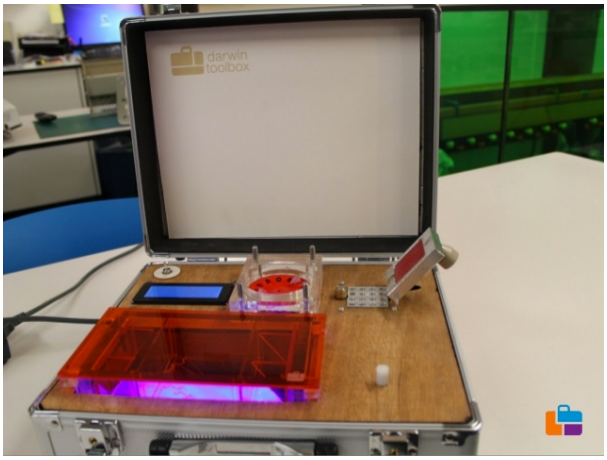
Let's look at two examples of great entrepreneurial projects.

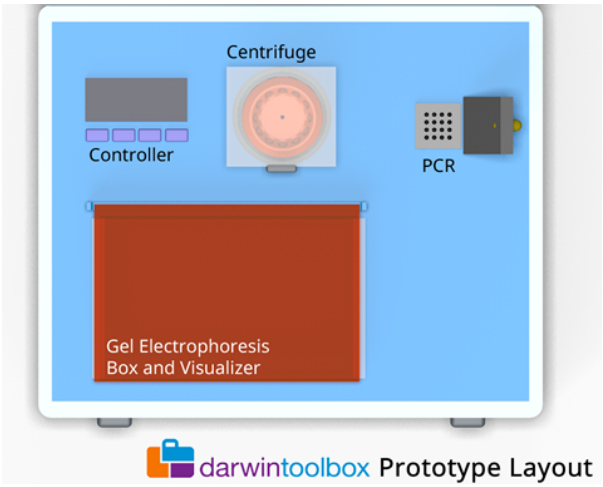
UCL 2013 E

http://2013.igem.org/Team:UCL_E

Another excellent example is the Darwin Toolbox, a hardware project presented by the **2013 UCL iGEM entrepreneurship team** (http://2013.igem.org/Team:UCL_E). They wanted to address lack of widely available synthetic biology tools by making a cheap, safe, user-friendly lab-in-a-box for high schools and community labs

They built a functional prototype lab and brought it to the Jamboree, but it was unclear if they had incorporated user feedback into their device by the time of the Jamboree or if they had any committed customers. After coming across some trademark issues, Darwin Toolbox rebranded as **Bento Bio** (http://www.bento.bio/) and have continued to work on their project. In 2015, the project was successfully funded on Kickstarter to launch mass production.





Calgary Entrepreneurial 2013

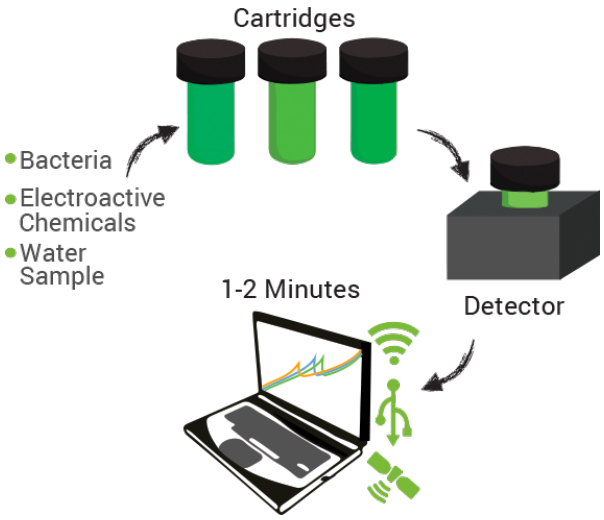
http://2013.igem.org/Team:Calgary_Entrepreneurial

FREDsense was the **2013 Calgary Entrepreneurship** (**http://2013.igem.org/Team:Calgary_Entrepreneurial**) team project. This project was continued from the 2012 North America regional championship award-winning Calgary project, with a focus on commercialization. The team focused on building their environmental toxin sensor into a product that was adapted to address pollution concerns surrounding shale oil production in Northern Alberta.

Before attending the Jamboree, they filed a provisional patent to protect their ideas against disclosure in a public forum, showing forethought in terms of IP strategy.

The team won the Entrepreneurship division in 2013 and went on to build a business after the Jamboree. It is not clear how much they talked with customers or had letters of intent to purchase functional prototypes of production units of their sensor before the 2013 Jamboree.

FREDsense™ Technologies



Product Design NEW

formerly Applied Design

Summary

- This prize awards the development of a synthetic biology product that solves a real-world problem in an elegant way
- Factors to consider in assessing product design include:
    - how well the product addresses the problem versus other potential solutions
    - how the product integrates or disrupts other products and processes
    - how the product can more broadly impact our lives and environments in positive and negative ways

Numerous iGEM teams have used their creativity to create potential consumer and professional products using synthetic biology principles. This special prize was created to reward the very best examples of this.

Applied design projects are judged on the following aspects:

1. **Does the team's synthetic biology product address a real-world need?**
2. **Does their product successfully incorporate synthetic biology into its design?**
3. **How impressive was the demonstration (at the Giant Jamboree or through video) and documentation of their product?**
4. **How well did the team engage with potential users and/or experts and incorporate feedback into the product design?**
5. **Has the team thoughtfully considered the positive and negative implications of their product?**

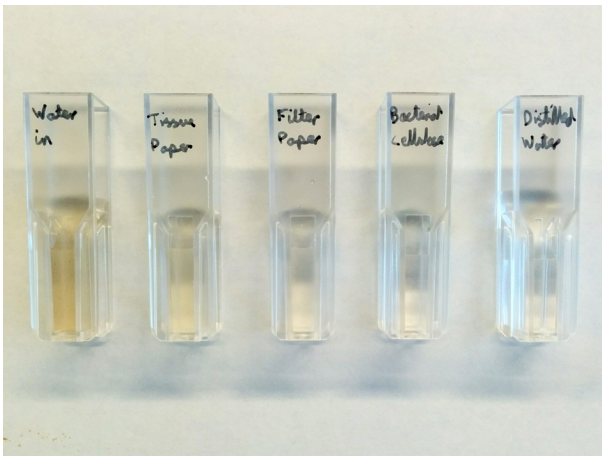
Next, let's see how these aspects are applied to one example team.

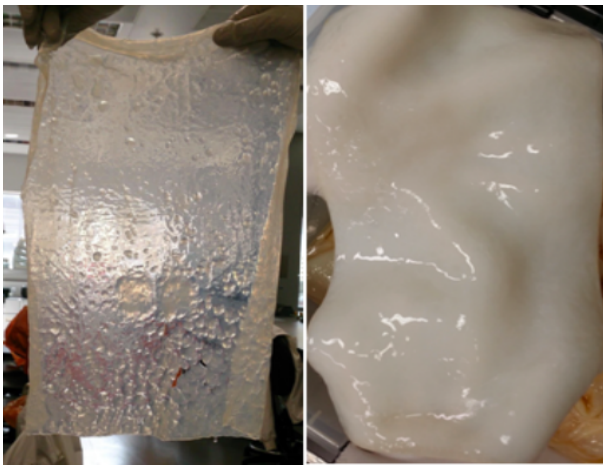
Imperial College London 2014

http://2014.igem.org/Team:Imperial/Art_and_Design

This team used bioengineered bacterial cellulose, commonly associated with kombucha, to create a water filtration system. First, they engineered the bacteria to produce metal binding enzymes, which would better capture metals like zinc and nickel as water passed through the filter, addressing a real-world need using synthetic biology (**aspects 1 and 2**). The thoroughness of the product development was impressive. For example, team members worked with designers to brainstorm applications for their bacterial mat before settling on water filtration as their goal. Crucially, they also met with experts in the field of water purification—including Thames Water, a private utility company responsible for water supply and wastewater treatment in large parts of London, to more deeply understand the problem they were trying to solve and understand how their project might fit into existing infrastructures.

Finally, they consulted with local artists and designers to address the aesthetic potential of their product (**aspect 4**). Samples of their cellulose were available to touch and interact with at the Jamboree, and the team included videos and numerous extensive photographic and written documentation of their product on their wiki (**aspect 3**). Finally, through their human practices work, the team did address many of the positive implications of their work (**aspect 5**). The product weaknesses could likely have been more strongly addressed, but the product and overall project were extremely strong as a whole, leading Imperial to a final placement as 1st runner up in the Undergraduate section.





Software Tool

Summary

- Software tools are often created by parts-based (wetlab) teams to support a need in synthetic biology.
- Excellent tools should be both novel and useful to others in the field, aiding some part of wetlab project design or execution in various types of projects.
- The software should be user-friendly and have good documentation.

Teams can generate software that goes on github, so if you don't feel comfortable, please get in touch so that the Executive Judging Committee can help you find a judge with technical software competency to help you evaluate the project.

However, teams applying for the software tool award should have built something that can be used and evaluated by non-experts, so please take this into consideration during your evaluation. The purpose of this award is to make something that other teams can use.

The software tool rubric is as follows:

1. **How well is the software using and supporting existing synthetic biology standards and platforms?**
2. **Was this software validated by experimental work?**
3. **Is it useful to other projects?**
4. **Does the team demonstrate that their software can be embedded in new workflows?**
5. **How user-friendly is the software?**

Let's look at one example of a great software tool.

Valencia UPV 2016

http://2016.igem.org/Team:Valencia_UPV/Software

The software tool, as described by the team:

"In order to ease the use of HYPE-IT we have developed a web application. Its two pillars are: a database which has genomic information related in a cause-effect way with the phenotypic trait regulated by that gene, and a scoring system which returns to the user all possible gRNAs of that gene, from highest to lowest score. Given a gene, the scoring system returns all possible gRNAs with their associated scores and primers for Goldenbraid standard. Our scoring algorithm has been developed from laboratory studies and criteria accepted by scientific community, being our best target always within the top 5 suggested by other tools commonly used. Usability has been a priority in the web design.

It includes techniques such as routing by the standard REST and web design standards, including a template externally developed. Thus, we have created not only a technical tool, but also a user-friendly online collaborative network."

The team's Hack Your Plants Editing with Innovative Technologies (HACK-IT) project was about making plants easier to engineer using simplified CRISPR Cas9 tools. The team developed a split Cas9 system to bypass the issue of transforming a single huge coding sequence into plants. This viral approach allows delivery of the editing machinery and guide RNAs (gRNAs) to the plant without the use of agrobacterium-mediated transformations.

The software component of the project allows the optimal gRNAs to be selected from a database of different plants and genes.

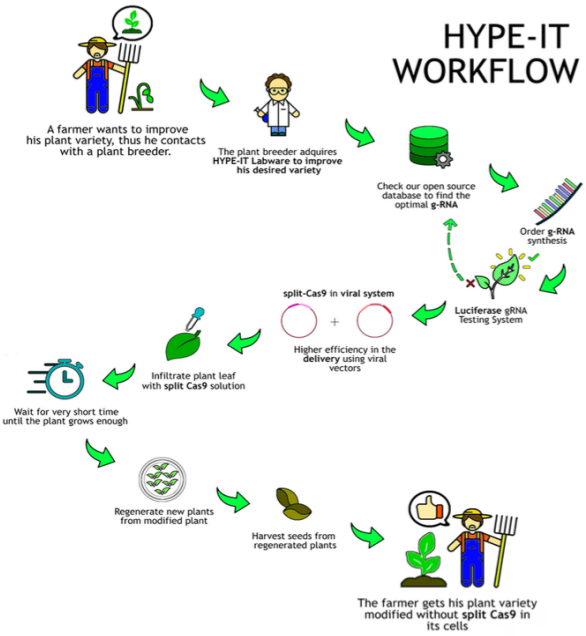
Like many software teams, Valencia have created an external website where judges and the public can access their work: **hypeit.cloudno.de** (**http://hypeit.cloudno.de/**)

While iGEM generally penalizes teams for hosting content off the iGEM servers, the software tool is one award where this is acceptable, as many teams need to implement software frameworks that cannot be installed on the iGEM servers.

In terms of the software, the team scored very highly in every category, with the exception of aspect 5. This may be because users need to register to use the program, and the team may not have been responsive to the judges in the weeks coming up to the Jamboree, or the judges may not have registered to use it. Judging feedback on this issue also mentioned a lack of adequate documentation and explanations on the wiki.

The HYPE-IT software makes use of a database of guide RNAs that integrates well into synthetic biology and iGEM by the use of a Phytobrick parts collection. These parts allow users to perform their own plant transformations using CRISPR on a number of plant chassis. Creating a part collection and characterizing this collection also satisfies the experimental validation criterion.

The team also thought about how to make this tool a part of new workflows, as shown by their workflow diagram.



Hardware

Summary

- The Hardware special prize was created to recognize the development of novel and useful devices designed to aid those working in synthetic biology
- Strong competitors for this prize will demonstrate utility, user testing, and easy reproducibility by those in the community.

Over the duration of iGEM, many teams have built hardware devices and brought them to the Jamborees. The Hardware special prize was introduced to reward Standard Track teams who also took the time and effort to develop a unique piece of synthetic biology-related hardware. As with all special prizes, the Hardware special prize winner will be determined by a specific section in the judging ballot, where the language is tailored more exactly to the nature of the prize.

In the case of the Hardware special prize, the aspects are as follows:

1. **Does the hardware address a need or problem in synthetic biology?**
2. **Did the team conduct user testing and learn from user feedback?**
3. **Did the team demonstrate utility and functionality in their hardware proof of concept?**
4. **Is the documentation of the hardware system sufficient to enable reproduction by other teams?**

Let's look at one hardware example.

Cambridge-JIC 2015

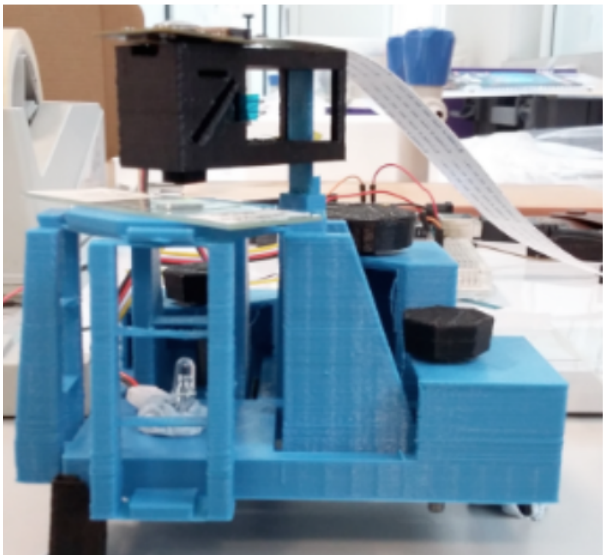
http://2015.igem.org/Team:Cambridge-JIC

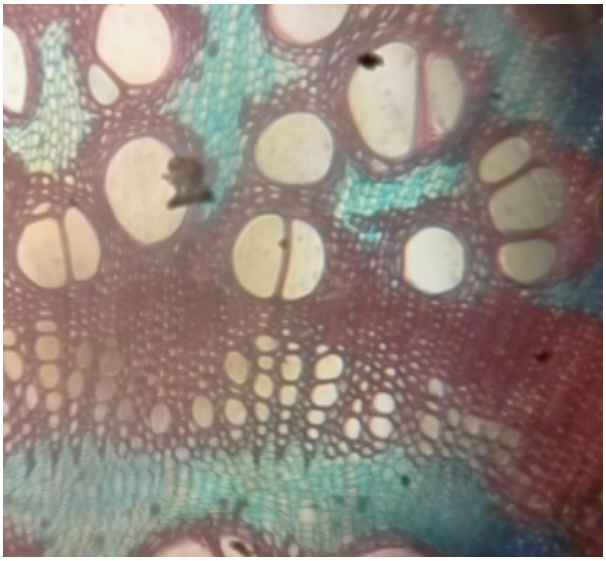
Cambridge-JIC developed an open-source, low-cost, 3D printed microscope based on a Raspberry Pi computer and camera named the “Openscope”. It can be difficult to get access to microscopes, so the problem they chose to solve is creating a low-cost variant that almost anyone can build for their lab using easily available materials and 3D-printing files (**aspect 1**). They designed several versions of their scope: manual, GFP, and motorized stage.

Cambridge-JIC worked hard to create a comprehensive (bill of materials **BOM** (http://2015.igem.org/wiki/images/d/d0/CamJIC-OpenScope-BOM.pdf) as well extensive **documentation with 3D printing files** (http://2015.igem.org/Team:Cambridge-JIC/Downloads) so that others can assemble materials to easily reproduce the device (**aspect 4**).

Although they did a good deal of testing on their own (including using biological samples from other teams), one way in which they could have strengthened their project would have been to see how well others would be able to use their design and instructions, and use resulting feedback to improve the scope (**aspect 2**).

Regardless of this, however, the utility and functionality of their prototype can be clearly seen in the brightfield image shown here (**aspect 3**).





Plant Synthetic Biology

formerly Advancement in Plant Synthetic Biology

Summary

- This award is designed to celebrate exemplary work done in plant synthetic biology. This award could also be given to a team working with algae or another photosynthetic chassis.
- Teams should address a problem or need unique to plant synthetic biology in their work.

Many teams have worked on plant projects in iGEM, starting as far back as 2010. Plant teams could tackle a wide variety of projects across many tracks and as such, we are supporting plants as a special prize and not a track. Teams have submitted parts from multiple plant chassis and we have a collections page on the Registry with more information: **http://parts.igem.org/Collections/Plants**.

The Plant Synthetic Biology special prize is judged according to the following aspects:

1. **How successful was the team in engineering a plant or algal cell?**
2. **Does their work address a need or problem in plant synthetic biology?**
3. **How well did the team use the special attributes of the plant chassis?**
4. **Are the parts/tools/protocols for plants made during this project useful to other teams?**

Next, let's see how these aspects are applied to one example team.

Cambridge-JIC 2016

http://2016.igem.org/Team:Cambridge-JIC

The Cambridge-JIC 2016 team built a toolbox for chloroplast transformation (**aspect 2**) and worked on optimizing the transformation protocol for Chlamydomonas reinhardtii, which is a single celled chlorophyte useful for synthetic biology applications as it has very efficient protein expression compared to other systems (**aspect 3**). During the course of their work, the team built a library of tested parts optimised for Chlamydomonas and related chloroplasts to facilitate the assembly of synthetic constructs using the PhytoBricks standard (**aspect 1, 4**).

Research in the chloroplasts of microalgae, such as Chlamydomonas reinhardtii, is likely to be applicable to studies of other plants (**aspect 4**). They also built an inexpensive gene gun and growth chamber and designed a tool which could help achieve essential homoplasmy (transformation of all copies of chloroplast DNA) in one generation instead of 2-3 months of selection (**aspect 4**).

Basic and Composite Parts

Summary

- The contribution of parts to the Registry is the fundamental backbone of iGEM. Prizes should be awarded to the best examples of part contributions
    - Basic parts are single genetic components (e.g., RBS)
    - Composite parts are combinations of components (e.g., promoter+RBS)
- Parts must follow Registry guidelines (automatically checked by the Judging Form)
- Your role is to check for details and quality. The best parts should:
    - Be highly documented on the Registry
    - Have detailed supporting data showing the part working
    - Have some novel and/or useful function

BioBricks are the main building elements of iGEM that allow other teams to build on the shoulders of the previous teams. Since many teams incorporate basic parts into new devices, the impact of good BioBricks can be seen for years in the iGEM and greater synthetic biology communities.

There are five aspects for assessment that you should keep in mind as you evaluate Basic and Composite Parts:

Best Basic Part aspects:

1. How does the documentation compare to BBa_K863006 (http://parts.igem.org/Part:BBa_K863006) and BBa_ K863001 (http://parts.igem.org/Part:BBa_K863001)?

2. How new/innovative is it?

3. Did the team show the part works as expected?

4. Is it useful to the community?

5. How well characterized (experimentally measured) is this Basic Part when tested in a device?

Best Composite Part aspects:

1. How does the documentation compare to BBa_K404122 (http://parts.igem.org/Part:BBa_K404122) and BBa_ K863005 (http://parts.igem.org/Part:BBa_K863005)?

2. How new/innovative is it?

3. Did the team show the part works as expected?

4. Is it useful to the community?

5. How well characterized (experimentally measured) is this Composite Part?

To satisfy Registry guidelines, the part must (1) be sent to iGEM HQ by the shipment deadline (October 10, 2018), (2) be in the pSB1C3 vector, (3) be BioBrick (RFC10) compatible or an agreed exception (on a case-by-case basis), (4) meet the standards set by the Safety Committee, and (5) be documented on the Part's Main Page in the Registry.

Registry documentation should include:

- Basic description of the part
- Sequence and features
- Origin (organism)
- Experimental characterization
- Specific definition of the chassis and genetic context where it was demonstrated to work (and/or where it doesn't work)
- Potential applications
- Appropriate references from the primary literature

The process for judging Basic and Composite parts is almost identical. For both Basic and Composite parts, the teams must follow iGEM standards (ex: RFC10, pSB1C3 backbone), demonstrate usefulness of these parts to the wider iGEM community, and provide sufficient characterization and documentation so that future teams may use these parts in their projects. The major difference between Basic and Composite Part evaluation is in how the Part is tested experimentally. Basic Parts by themselves cannot be tested (ex: how would you test a promoter by itself?); they require a test device or other construct in which to be tested. Frequently, Composite Parts can stand alone and be tested but may also need a test device if the Composite Part is not a full transcriptional unit or similar.

From the perspective of creating a Registry that can be used long-term by scientists and engineers in the community, common issues with part documentation include:

- Figure axes and legends lacking important details about how the data was obtained (e.g., experimental design details, including strain and expression plasmid for protein-coding parts); the data on the Registry page should be able to stand alone, if possible
- Links to UniProt or other database for original sequence or literature references not provided for parts derived from a natural or de novo sources
- Information about which test device, if any, was used on the Registry documentation page (including relevant part numbers) to generate characterization data for parts. This is most commonly seen for Basic Parts.

Examples of Best Basic Parts are:

BBa_K2259000 (http://parts.igem.org/Part:BBa_K863006) (Explained on page 70)
BBa_K863006 (http://parts.igem.org/Part:BBa_K863006)
BBa_K863001 (http://parts.igem.org/Part:BBa_K863001)

Composite Parts Examples

The aspects for Composite Parts are the same as for Basic Parts.

You may look at the examples for The Best Composite Parts for iGEM 2017 which are below:

BBa_K2259091 (http://parts.igem.org/Part:BBa_K2259091) made by Vilnius-Lithuania Undergrad Section

BBa_K2306008 (http://parts.igem.org/Part:BBa_K2306008) made by TUDelft Overgrad Section

BBa_K2206006 (http://parts.igem.org/Part:BBa_K2206006) made by CLSB-UK High School Section

Best Basic Part (BBa_K2259000)

http://parts.igem.org/Part:BBa_K2259000

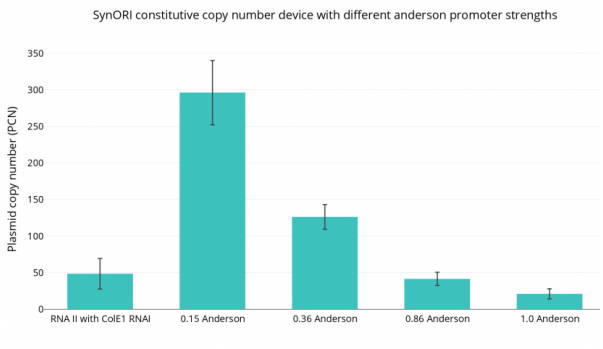
This basic part contains RNA II that acts as a plasmid replication initiator and is an essential biobrick for the framework of a multi –plasmid system (SynORI) which was created by the **Vilnius-Lithuania 2017 iGEM team** (http://2017.igem.org/Team:Vilnius-Lithuania). It is also one of the parts in their parts collection that won the Best Part Collection undergrad section (http://2017.igem.org/Team:Vilnius-Lithuania/Part_Collection).

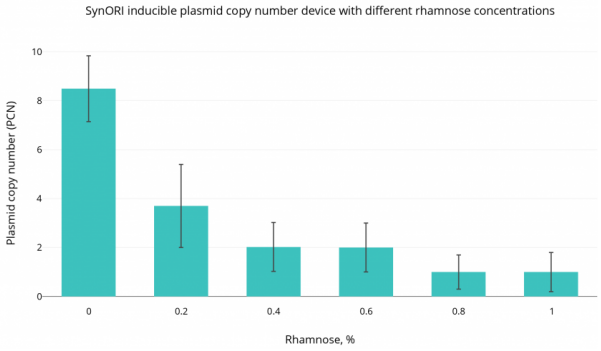
As seen in aspect 1 of the rubric, the team have extensively documented their Part on the Parts Registry. They give an overview of the basic biology of plasmid replication and, why their part was important and innovative and a list of references (**aspect 2**). The team's characterization of the basic part was impressive.

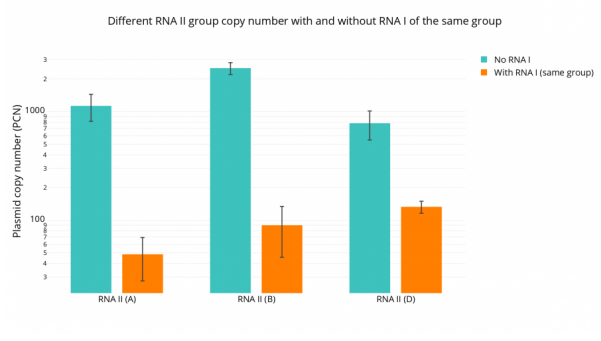
First, they looked at the plasmid copy number to see if the RNA II was working, they then used different Anderson promoter strengths and proved that they could control the plasmid copy number in a constitutive manner and also they showed that the plasmid copy number could be controlled in an inducible manner (**aspect 3**).

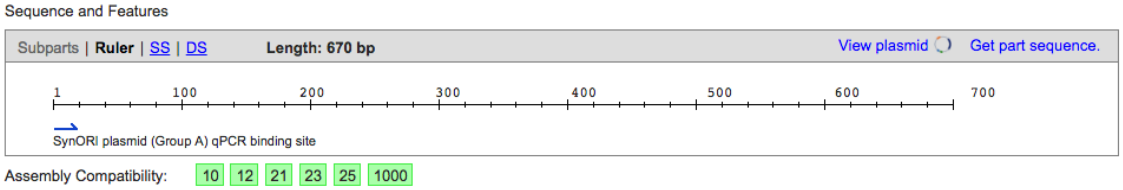
The team have also showed that that RNA I works specifically with RNA II with different groups of their synORI system to control the plasmid copy number as proof of concept (**aspect 5**).

To satisfy the Registry guidelines, we can clearly see that this part is compatible with RFC10, as there is a green box labeled "10" next to "Assembly Compatibility". Therefore, this part is accepted in the part status check.









Part Collection

Summary

- Collections should exemplify a ***system*** of parts that can be applied to other situations by other teams (e.g., framework for a measurement system). The collection of parts should perform a useful or specific function for the community.
- A collection must contain at least 3 parts but there is no upper limit to the number of parts a team can submit.
    - Only parts that teams have submitted can be eligible for this award, so anything that does not pass the part status check should be disregarded.

The most important factor to consider when evaluating the part collection award is how the parts are related. Is it a real collection, or have the team just submitted all the parts they made in the hope of winning this award? If this is the case, you should disregard the team's entry as the award should only be given to a team who has made a real collection (i.e., a set of parts that together perform a function).

The Part Collection special prize is judged according to the following aspects:

1. **Is this collection a coherent group of parts meant to be used as a collection, or just a list of all the parts the team made?**
2. **How does the documentation compare to the BBa_K747000-095 collection?**
3. **Did the team submit a complete collection allowing it to be used without any further manipulation or parts from outside of the Registry?**
4. **Did the team finish building a functional system using this collection?**
5. **Is it useful to the community?**

Part Collection Examples

Here are some great examples of Part Collections.

Vilnius-Lithuania 2017

http://2017.igem.org/Team:Vilnius-Lithuania/Part_Collection

The Vilnius-Lithuania 2017 team created a large and extensive part collection in which each piece has a different specific function, however they all consolidate for a common purpose of creating a flexible and precise multi-plasmid system.

Part Range: BBa_K2259000 - K2259080

Arizona State 2016

http://2016.igem.org/Team:Arizona_State/Part_Collection

The Arizona State 2016 team created a part collection that had all of the components to N-acyl homoserine lactone (AHL) quorum sensing system.

Part Range: BBa_K2033000 - K2033011

Peking 2015

http://2015.igem.org/Team:Peking/Part_Collection

The Peking 2015 team combined the specific sequence binding activity of dCas9 with diverse characteristics of split enzymes, thus creating a part collection named “PC Reporters Collection”.

Part Range: BBa_K1689007 - K1689020

Freiburg 2012

http://2012.igem.org/Team:Freiburg/Parts

The Freiburg 2012 team made a single pot TALEN DNA binding domain construction kit

Part Range: BBa_K747000 - K747102

Wiki

Summary

- The wiki is meant to be the primary permanent record of a team's project, including a description of who did which parts of the project.
- A great wiki will be visually appealing, concise, and easily navigable.
- All project details should be included, but it should be clear where to find the key information.

In iGEM, the purpose of the team wiki is to publicly provide full project details to future teams, researchers, and the general public in an organized, visually appealing manner.

These details can and should include everything needed to reconstruct the project from the ground up, including the project goals, background information, research strategies, a lab notebook, experimental results, protocols, model documentation, results, safety information, BioBrick parts made, etc.

The wiki is the very first thing a judge sees when assessing one of his or her assigned teams, as the wiki evaluation occurs before the Jamboree begins.

Characteristics like whether or not a wiki is informational, easy to navigate, or visually appealing can make a big impact on a team's critical first impression to the judging body. There are five aspects for wiki assessment that you should keep in mind as you explore the team's wiki.

1. **Do I understand what the team accomplished?**
2. **Is the wiki attractive and easy to navigate?**
3. **Does the team clearly document their project and support their results with convincing evidence?**
4. **How well does the team describe what they did and what was done by others on the Attributions page?**
5. **Will the wiki be a compelling record of the team's project for future teams?**

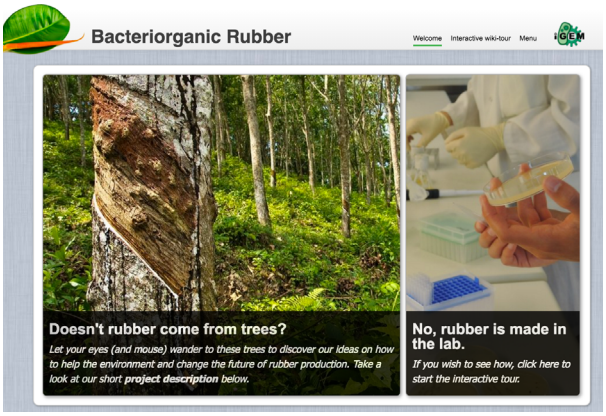
Let's look at one example of a winning team wiki.

SDU-Denmark 2013

http://2013.igem.org/Team:SDU-Denmark

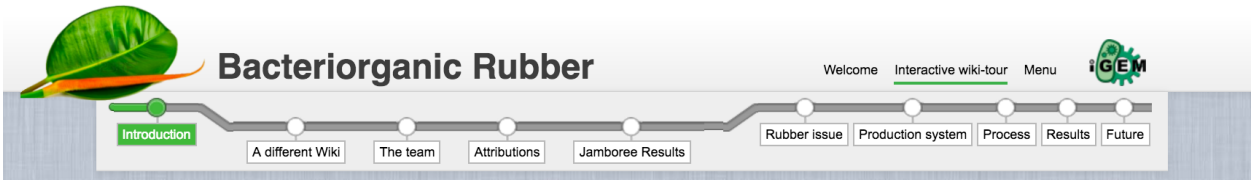
Looking at the front page for the SDU-Denmark wiki, we can see that the color scheme and layout is visually appealing (**aspect 2**). It is formatted in such a way that the eye is drawn to the critical information – in this case, the motivation and basic idea behind their project: making rubber using bacteria instead of trees.

We also see an invitation to join an interactive tour of their project. While this type of feature is not required and is not necessarily standard, it allows the team to tell their story in the most advantageous manner possible. If we start the tour, we are taken to the image in the next page.



From the very beginning of their tour, SDU-Denmark has made it very easy for a judge to find the answers to **aspects 3 and 4** regarding data and attributions. However, for a viewer less interested in these Jamboree-specific questions, one can simply skip to the next chapter ("Rubber Issue") that deals more with the story behind their project.

Navigationally, this wiki also allows a viewer to easily jump to any particular section of interest by hovering over the "Menu" link.



The ease of navigation of this wiki (**aspect 2)** is just one characteristic that makes it deserving of the Best Wiki award. If we look more into the "guts" of the wiki, we find a wealth of information about the project, including in-line links to their references (reached by hovering over the speech bubble icons) (aspect 4).

The information is laid out in a way that is visually easy to read and uses language that is easy to understand (**aspects 1 and 2**). In the results section, we find detailed descriptions of their entire experimental process, including dozens of publication-level figures that can be opened up in-screen for more detail (**aspect 3**).

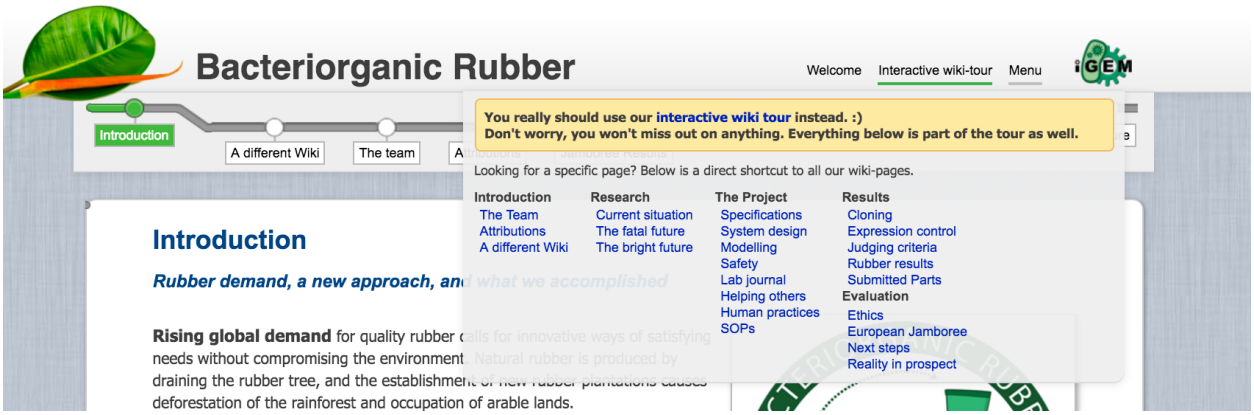
SDU Denmark made such a remarkable attempt at ensuring their wiki was of the highest standard for the 2013 Jamboree, that they won the best wiki award again in 2014 with the same design! The attention to detail, layout, navigation and ease of use make their design one of the most compelling wiki records in the brief history of iGEM (**aspect 5**).

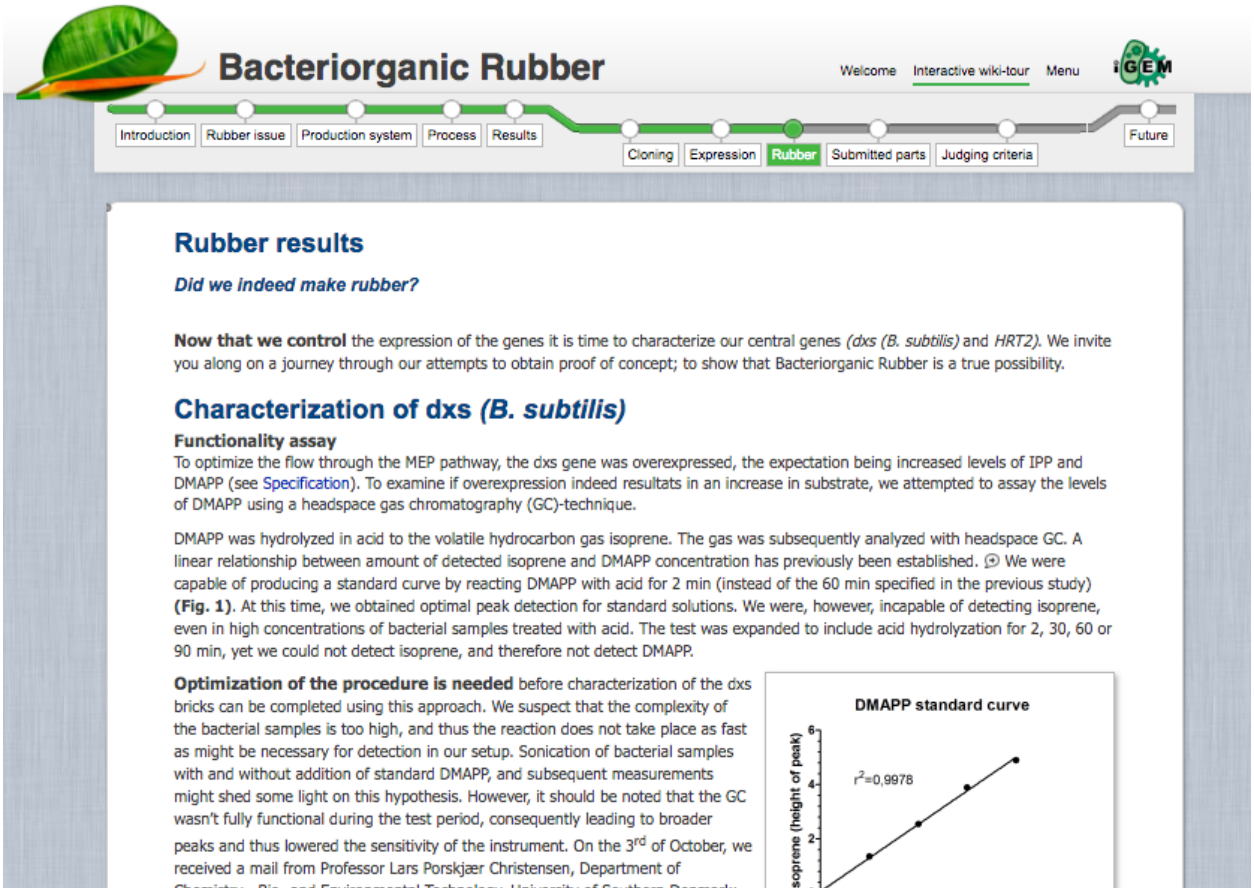
Finally, it is important to note that this wiki also follows all of the iGEM wiki requirements (e.g., all pages, images, and files are hosted on the iGEM server, NO flash, NO iframes etc). If any content is hosted off-site, the wiki is automatically disqualified from the Best Wiki award (as well as any medals).

The winning wiki is the first wiki that teams will look at in subsequent years, so it must be the best example in every way.

We can see why this wiki earned high marks in all of the judging aspects. However, this wiki has some additional characteristics that facilitate judging for other categories in the rubric: (1) a page listing their accomplishments in terms of medal criteria and (2) direct links to their BioBricks in the Registry of Standard Biological Parts.

Although these pages do not necessarily correspond to any of the aspects for wiki assessment, they can be very useful to a judge before, during, and after a team's presentation when he or she is looking for the answers to specific judging questions. The availability and organization of the information reflects well on the team project as a whole. Finally, SDU-Denmark also makes their wiki source code available to all teams, demonstrating the sense of worldwide camaraderie and collaboration that is so important in iGEM.





Presentation

Summary

- The presentation is the chance for a team to tell their story in a concise and visually appealing way.
- Teams have 20 minutes to give their presentation, followed by 5 minutes for questions from the judges and audience (if time allows)
- Excellent presentations will be engaging, easily understood by a broad audience, balance big-picture ideas with design details, and flow smoothly.
- Teams should answer post-presentation questions competently and concisely; further detailed discussions can be held during poster sessions.

Having a successful iGEM project goes beyond the project itself as teams should present their work in a clear and engaging manner and communicate their project to a broad audience. Above all, each team should tell a story as they present their work.

There are four aspects for assessment that you should keep in mind as you evaluate presentations:

1. **Was the presentation thorough, clear, and easy to understand?**
2. **How visually appealing was the presentation?**
3. **Did you find the presentation engaging?**
4. **How competent were the team members at answering questions?**

Let's look at one example of a winning presentation.

Dundee 2013

http://2013.igem.org/Team:Dundee

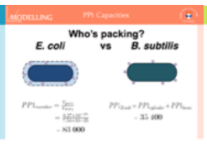
To explore an example of an outstanding team presentation, let's take a look at **Dundee 2013** (**http://2013.igem.org/Team:Dundee**) , the winner of the 2013 awards for Best Presentation, Europe, and Best Presentation, Undergrad (World Championship). First, you should definitely watch **Dundee's video** (**http://2013.igem.org/files/video/Dundee_Championship.mp4**) about targeting the toxin present in algal blooms.

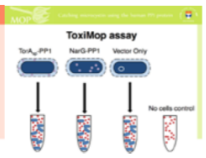
Their presentation is truly engaging and literally "kept me on the edge of my seat!" (**aspect 3**). Rather than separate each part of the project and have a team member talk about just that part, they told a story, connecting the different parts of the project.

They began with an overview of their project and described how the public was included in the project from its start. Rather than sticking the Human Practices component at the end of their presentation, they weaved HP into their story and addressed issues and concerns throughout the presentation.

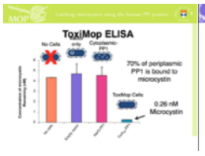
The presentation flowed (**aspect 1**) and led the audience to ask what's next. The three presenters made smooth and effortless transitions during the presentation. Speakers maintained eye contact with good voice quality. Their presentation style conveyed their excitement and enthusiasm for the project. Additionally, they introduced humor at timely and sometimes unexpected points during the presentation to keep the audience engaged.

Good quality and choice of images





Emphasis on engaging visuals with minimal text



Slides are easily readable, with appropriate sizes for fonts and resolutions for images

Clearly labeled graphs with error bars

Meaningful animations (nothing too fancy or flashy)

Also, it was clear that they practiced their talk, as their presentation was polished and professional. They even anticipated questions from the audience; they included extra slides at the end of their presentation, just in case (**aspect 5**).

Now let's focus on graphic design (**aspect 2**) – an impressive presentation would be error-free and need no verbal guidance. What can we say about the slides used in **Dundee's presentation:** (**http://2013.igem.org/files/presentation/Dundee_Championship.pdf**)? One thing that immediately stands out is that the slides are really clean! What does that mean? The slides had high overall appeal and delivered a clear message.

Here are some characteristics of those slides:

Another characteristic of a good presentation concerns the use of color. It's important that the choice and use of colors are not distracting and contribute to the understanding. During the presentation, Dundee used colors effectively in the headers on the slides. Each major part of their presentation had its own header to serve as a visual guide to the audience. Throughout the presentation, it was easy to see where the current slide fit into the overall project. This creative use of color with specific images and descriptive text greatly contributed to the clarity and flow in Dundee's presentation.

In summary, the Dundee 2013 presentation was recognized for its excellence in clarity (**aspect 1**), graphic design (**2**), and engagement of the audience (**3**).

Poster

Summary

- Posters should be a visual summary of a team's project that should be presented by the team during their assigned poster session.
- The poster should follow the poster guidelines and be appealing with nice visual flow. (Guidelines provided online here: **Poster Guidelines:** http://2018.igem.org/Competition/Deliverables/Poster)
- The poster session is the best opportunity for judges to talk with the team. During this time, you can ask more questions, compliment good work, and offer suggestions for improvements.
    - Teams love talking with judges, and judges often learn a lot of details at the poster session the would not have learned otherwise!

In iGEM, the purpose of the poster is to communicate the project to others in a very concise, yet engaging manner. There are four aspects for assessment that you should keep in mind as you evaluate posters:

1. **Did the poster flow well?**
2. **How well is the project described on their poster?**
3. **Did you find the poster visually appealing?**
4. **How competent were the team members at answering questions?**

Judges should take a first pass at evaluating posters during free sessions while the team is not present. Judging during a free session allows you to ascertain if a poster can stand on its own as a clear communication of the project. During the poster sessions, judges should visit the posters and discuss the projects with team members.

Although you may experience some communication issues if you and the students speak different native languages, you should be able to distinguish between communication problems and a lack of knowledge of the project. Evaluations of both the displayed poster and the oral presentation of the poster factor into the awarding of the Best Poster prize.

As a judge, you should have the following expectations of teams at the poster session:

- Posters should be set up for display by Thursday morning after the Opening Ceremony is over and will remain up until Sunday.
- Team members should be present at their poster during their assigned poster session. Judges should not expect team members to be present during any of the team's non-assigned poster sessions.
- Other members of the iGEM community may be visiting the team's poster when you arrive at the team poster. Judges should be given priority during the poster reception because you have limited time to complete your judging responsibilities.
- Multiple team members may help answer the questions that you ask of the team. You should not expect a single team member to know every aspect of their project in detail, as team projects are generally very complex.
- Remember to explain to team members that they can relax during this process! A lot of students will be nervous when talking with a judge - it's your job to make sure they relax and do the best they can.

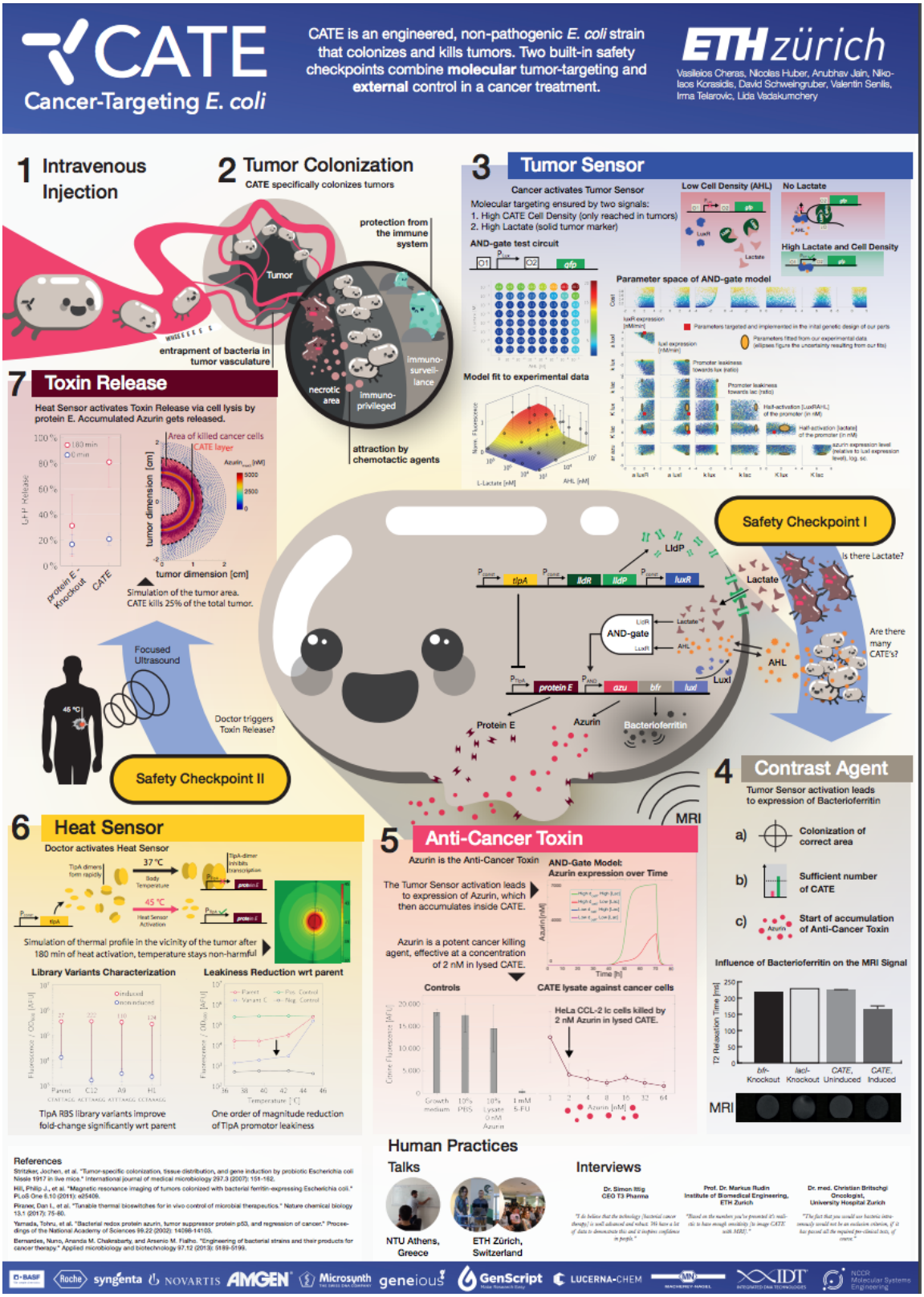
Please Note

In addition, some teams have elected to display supplemental materials at their poster station. These displays have included laptop/tablet presentations, team prepared pamphlets/handouts, and 3-D printed models. The supplemental materials will not be factored into the judging of the poster.

Let’s look at two examples of winning posters.

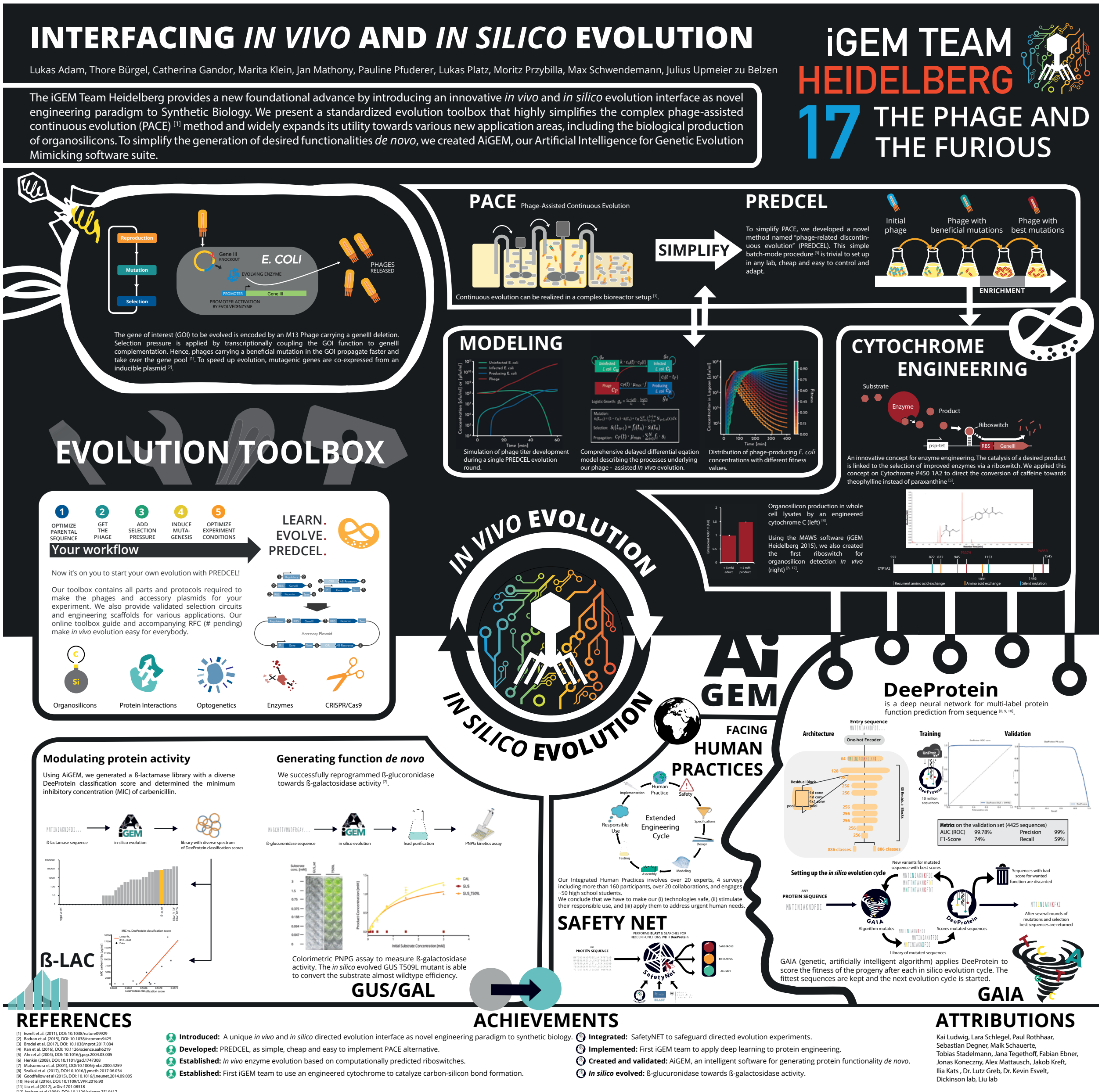
ETH Zurich 2017

http://2017.igem.org/Team:ETH_Zurich



Heildelberg 2017

http://2017.igem.org/Team:Heidelberg



CHAPTER 5

HIGH SCHOOL TEAMS

Introduction

Summary

- High School teams are considered a separate section of iGEM, just like the distinction between the Overgrad and Undergrad sections.
- All High School teams will be evaluated just like Standard Track teams, with the exception being that High School teams cannot choose a track distinction (e.g., energy, environment). As such, they are also treated as their own Standard Track.
- In the judging ballot, you should judge High School teams *just as you would a standard collegiate team*, but keep in mind the following:
    - High school students are often still deciding whether or not to pursue a career in science/engineering.
    - As a judge, your interactions with them could have a significant effect on their future career
    - *You should mark the ballot according to the language scale, but in your comments and discussions with the teams, remember the potential impact of your words!*

When judging high school teams, please keep in mind that many high school teams must deal with additional factors such as a smaller budget, lower availability of laboratory facilities, and shorter working hours, not to mention the fact that the students probably haven't taken any college-level courses yet! As a result, it can be considered a substantial achievement for a high school team to make a functioning part.

This is not to say that high school teams are not able to make interesting and significant contributions to synthetic biology. In fact, it can be difficult to distinguish between the best high school teams and many collegiate teams. To demonstrate this idea, let's look in detail at a couple of teams.

Let's look at two examples of winning High School teams.

TAS Taipei 2017

http://2017.igem.org/Team:TAS_Taipei

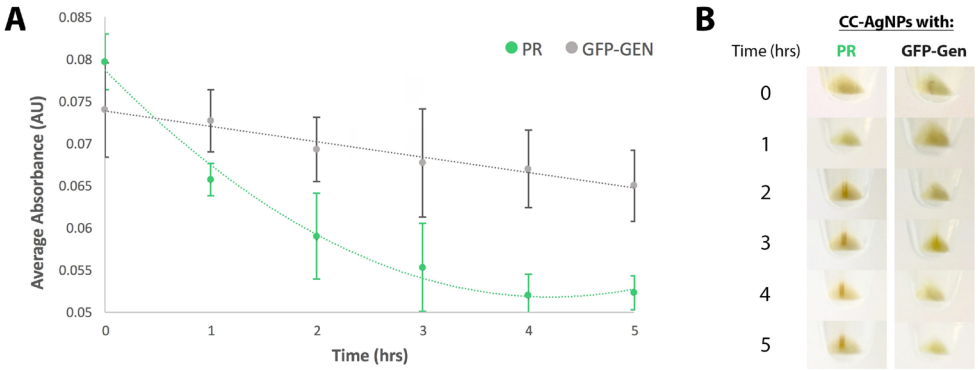
In 2017, the team **TAS Taipei** (**http://2017.igem.org/Team:TAS_Taipei**) impressed the judges with their project, Nanotrap: Nanoparticle Removal from Wastewater Systems. They not only won the High School Grand Prize trophy, but they were also awarded Best Wiki and were nominated for Best Presentation, Best Poster, Best Integrated Human Practices, and Best Part Collection.

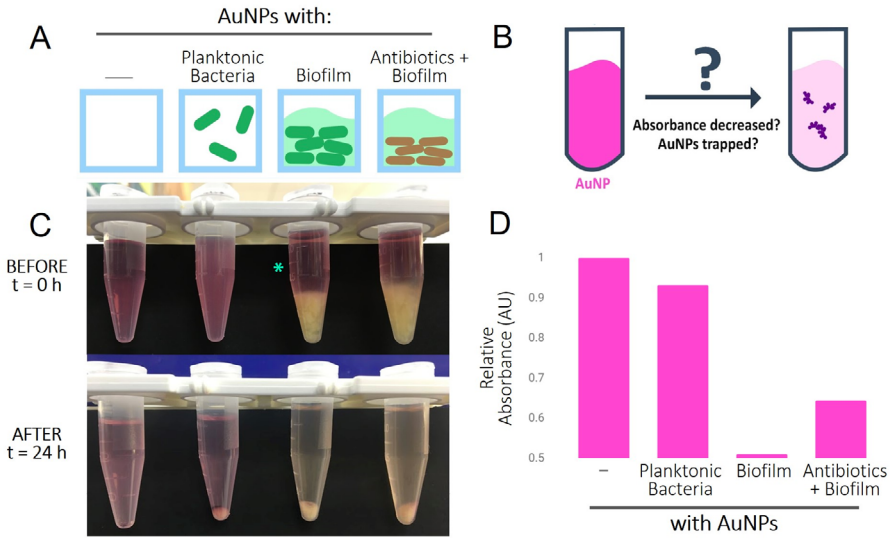
TAS Taipei's project revolves around nanoparticles, common additives in consumer products, including sunscreens, makeup, and athletic clothing. Due to the pervasiveness of nanoparticles in products, it is estimated that several hundred tons of nanoparticles are entering our wastewater each year, potentially causing significant negative environmental and health effects.

The team took a two-pronged approach in their solution to remove nanoparticles from wastewater.

Proteorhodopsin receptors to bind citrate, a common capping agent in nanoparticle synthesis. Production of biofilms in E. coli to capture the nanoparticles not capped with citrate

For the first part of their project, they designed a part to express a proteorhodopsin receptor (PR) in E. coli. They then tested their modified bacteria to see if they could trap citrate-capped nanoparticles (see figure).





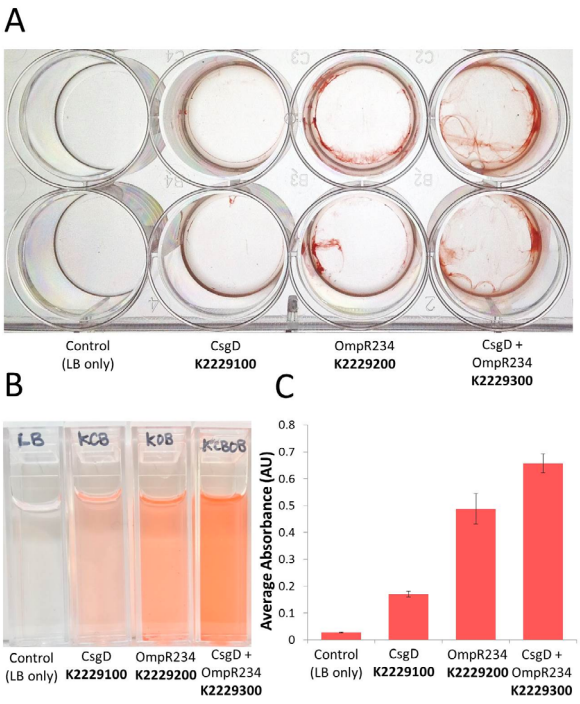
As seen in their experimental results, the strain containing PR shows a decrease in absorption relating to nanoparticle presence over time, and the cell pellets show an increased dark mark corresponding to nanoparticle collection. It is clear that this part works to bind nanoparticles from solution.

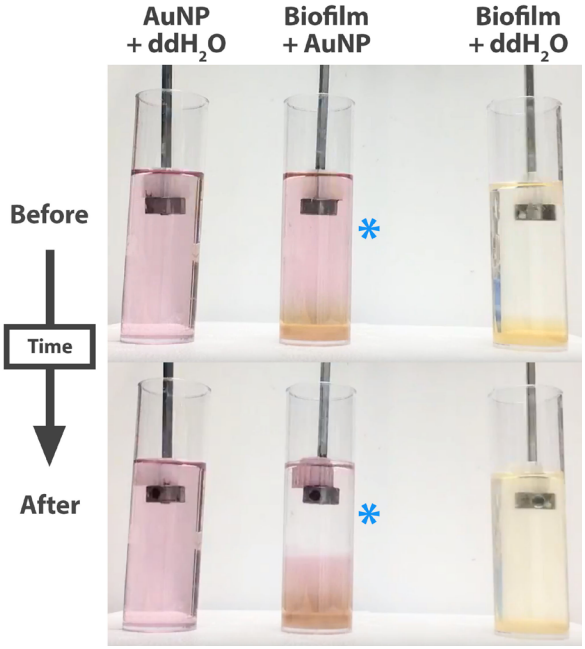
For the second part of their project, the team first attempted a proof of concept study to see if biofilms could trap nanoparticles. As seen in the second figure, they saw a decrease in absorbance corresponding to nanoparticle presence when biofilms were present (even when the biofilms were treated with antibiotics to kill the living cells).

After verifying their idea, the team's next step was to design parts in E. coli that would enhance biofilm production. They decided to overexpress the curli operon using two different genes, csgD and ompR234. When expressed, these genes both successfully increased biofilm production, and the combination of the two increased biofilm production to an even greater extent (see third figure).

Even after showing that their parts worked fairly effectively, the team took it a step further by modeling their system and using that model to estimate the kinetic parameters of binding/cell trapping, and then creating a calculator tool to estimate how much of their E. coli you would need to treat a certain amount of nanoparticles.

Finally, the team did work to see how well their system would work in a real wastewater treatment-style setup. They found initially that current styles of wastewater treatment would not be sufficient for trapping nanoparticles, but by making a few simple changes, such as the addition of a biofilm "carrier", their biofilm-creating E. coli could be adapted for sedimentation tanks.





In judging this team, we can reflect on the aspects of the "Project" part of the rubric:

1. How impressive is this project?

2. How creative is the team's project?

3. Did the project work?

4. How much did the team accomplish (addressed a real world problem, produced functional BioBricks, carried out Human Practices, created a wiki, presentation, poster, etc.)?

5. Is the project likely to have an impact?

6. How well were engineering principles (for example: modularity, prototyping, debugging, standardized measurements, etc.) used?

7. How thoughtful and thorough was the team's consideration of human practices?

8. How much of the work did the team do themselves and how much was done by others?

9. Did the team design a project based on synthetic biology and standard parts?

10. Are the parts' functions and behavior well-documented in the Registry?

TAS Taipei demonstrated an impressive number of accomplishments (**aspects 1 and 4**), and did so with a high level of engineering design and scientific quality (**aspect 6**), as seen by their use of controls, proof-of-concept experiments, and prototyping. Furthermore, the project clearly works (**aspect 3**) and, as seen in the figure captions throughout the wiki and on the attributions page, the students themselves likely did most of the work (**aspect 8**).

Even though the parts themselves are not necessarily complicated or creative (only the proteorhodopsin receptor gene was new to the Registry), the project is definitely based on synthetic biology and standard parts (**aspect 9**), and the parts they used are well-documented in the Registry (**aspect 10**). In their discussion of how to apply their project to real wastewater treatment, they were clearly thoughtful with regards to Human Practices (**aspect 7**), and it is possible that the project could have an impact (**aspect 5**), since microbes are already a significant part of the wastewater treatment process. In summary, TAS Taipei 2017 is an excellent example of a top-notch High School iGEM project.

Lethbridge 2013

http://2013hs.igem.org/Team:Lethbridge_Canada

Lethbridge Canada was the grand prize winner for the 2013 High School division competition. Their project aimed to produce a natural form of oxytocin and attach it to a carrier molecule to prevent the breakdown of oxytocin.

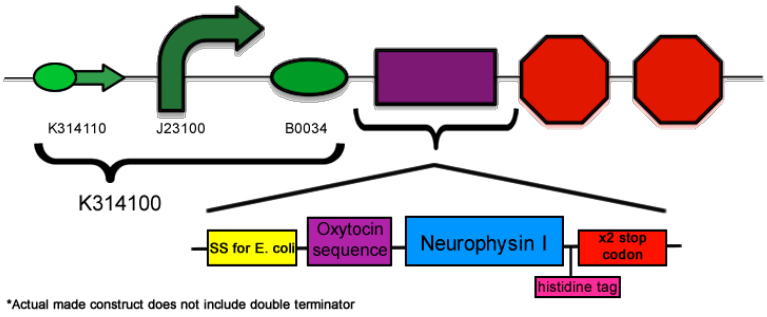
Normally, oxytocin breaks down quite rapidly, making it difficult to use in the lab or as a therapeutic agent. This ambitious project was well received for two main reasons: thorough research and design of their two constructs and clear explanations of their methods and results.

The team designed two constructs. The first was to express the maximum amount of oxytocin, along with its carrier protein neurophysin I. The team modified their construct with both an E. coli signal sequence for extracellular export and a histidine tag for detection.

The team was able to completely clone this part, as shown by the experimental data: **http://2013hs.igem.org/Team:Lethbridge_Canada/results** on their wiki. Even more impressive, the team was able to express the protein, as evidenced by a slot blot.

Lethbridge designed a second construct that would allow them to test many different promoters by combining them with mCherry. The idea of this construct was that it would give them a better idea of which promoter to use to maximize output of a secondary enzyme. Unfortunately, they did not have time to fully investigate the expression with different promoters.

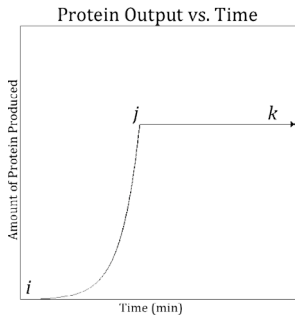
However, they used **mathematical modeling** (**http://2013hs.igem.org/Team:Lethbridge_Canada/math**) to help determine the correct promoter to use. Although the model is fairly basic, it is well documented and thoroughly explained on their wiki.



ANTI-HIS SLOT BLOT

Lane #	Contents
Lane 1:	100µL Oxytocin in 200µL TBS
Lane 2:	200µL Oxytocin in 100µL TBS
Lane 3:	250µL Oxytocin in 50µL TBS
Lane 4:	300µL Oxytocin
Lane 5:	25pM TruB-His positive control

$$n_p = \begin{cases} \int_i^j \left(b_i 2^{\frac{t}{30\text{min}}}\right)\left[\left(\frac{4200\text{nt/min}}{l_{tgene}}\right)\left(\frac{1}{2}\right)^{\frac{t_k}{t_h}}\right]\left(\frac{12\cdot\text{RBS}}{7}\right)dt, i \le t \le j \\ \int_j^k \left(b_i 2^{\frac{j}{30\text{min}}}\right)\left[\left(\frac{4200\text{nt/min}}{l_{tgene}}\right)\left(\frac{1}{2}\right)^{\frac{t_k}{t_h}}\right]\left(\frac{12\cdot\text{RBS}}{7}\right)dt, j \le t \end{cases}$$



Furthermore, the team made extensive connections between their project and their community through a variety of human practices activities, including interviews with local health professionals, discussions with their school boards, and surveys of their parents' attitudes towards iGEM and their participation in it (**aspect 7**).

In conclusion, this project was successful for multiple reasons:

1. The team used thorough (and attributed) background research to design a novel, elegant system to produce biological oxytocin.
2. They successfully cloned and expressed one of their constructs, and they posted their sequences and designs to the Registry.
3. They performed mathematical modeling to describe how their system would function in vitro.
4. Their wiki, presentation, and poster were simple, clear, and to the point.
5. They connected their project to their community through multiple human practices projects.

In short, Lethbridge Canada 2013 completed all of the tasks normally associated with a successful parts-based iGEM project. Although the level of detail and complexity of the project are somewhat lower than most collegiate projects, the team was able to succeed in a number of difficult challenges (e.g., making a working part, using modeling in lieu of experimental work) and effectively communicate their project to a broad audience (**aspects 1, 3, and 4**). These qualities made Lethbridge Canada a winning high school team.

CHAPTER 6

SPECIAL TRACKS

Introduction

Special tracks in iGEM are how students and members of the community participate in iGEM in areas that do not necessarily require submission of BioBricks. We evaluate these teams differently, without the need to award them medals based on parts. Thus, we can be inclusive of all types of teams from different schools.

These teams will also have priority for using the exhibition space at the Giant Jamboree. The intention is to enable teams to bring the materials they have produced to the Jamboree, e.g artwork, robots, measurement devices, and software demos, and show them off to our community.

Special Tracks benefit from more freedom within the competition because they are not required to work with BioBrick Parts and can define their work on their own terms; as such they **are not competing for the Grand Prize**.

There are two Special Tracks in iGEM in 2018:

- **Open**
- **Software**

The most significant difference between standard iGEM tracks and Special Tracks are the medal criteria. Please refer to pages 38 - 40 for the medal requirements for the Special Tracks. Neither of these tracks are evaluated on BioBrick parts. They can still make parts if they choose, but there is no specific mention of parts in the medal criteria for teams in these tracks. Additionally, Special Tracks are not usually split into undergraduate and overgraduate sections.

Below are the aspects from the “Project” section of the rubric for Special Tracks. Aspects 1-8 are the same for all iGEM teams, with aspects 9 and 10 specific to Special Tracks:

1. **How impressive is this project?**
2. **How creative is the team’s project?**
3. **Did the project work?**
4. **How much did the team accomplish (addressed a real world problem, carried out Human Practices, created a wiki, presentation, poster, etc.)?**
5. **Is the project likely to have an impact?**
6. **How well were engineering principles (for example: modularity, prototyping, debugging, standardized measurements, etc.) used?**
7. **How thoughtful and thorough was the team’s consideration of human practices?**
8. **How much of the work did the team do themselves and how much was done by others?**
9. **Did the team design a project based on synthetic biology?**
10. **Are the project components (hardware, software, art & design, etc.) thoroughly documented on their wiki?**

Open Track NEW

Summary

- The Open Track is designed any team who wants to participate in iGEM and work on a synthetic biology project but who may not be working in the lab using DNA parts.
- This new track combines the previous Special Tracks of Measurement, Hardware, and Art & Design, while also inviting teams to join the Open Track who want to work on other topics as well.

On the following pages are some example projects from previous Special Tracks: Art & Design, Hardware, and Measurement.

Art & Design Example

Teams that focus on art and/or design elements can use synthetic biology to reveal new problems in the world and to sometimes reflexively reveal problems with the aspirations of synthetic biology itself. These projects ask the difficult question of "Why?" Why do we think the way we do? And why can't it be otherwise? These projects are important because they ask us to rethink what we're doing.

Art Center MDP 2014

http://2014.igem.org/Team:ArtCenter_MDP

The winner of the 2014 Art & Design Track, the Art Center MDP team created "Car Pools," a project that imagined converting Los Angeles's swimming pools into a network of open ponds for biofuel producing algae. The project was a critique of current metropolitan sustainability practices: Los Angeles has a water problem. It depends on water piped from Northern California yet has 43,000 swimming pools, many of which are rarely used. At the same time, the city is famously dependent on cars and fossil fuels for transportation.

The project addressed both dependencies in one fell swoop with the improbable but clever solution of turning swimming pools into open ponds for algal fuel production. The power in this project is that it delved into the senselessness of the city's current geopolitics and asks why can't this be different.

The seemingly absurd solution the team posed may in fact be more logical than the city's current situation. The team went even further by taking its premise seriously through a series of experiments and demonstrations that explore the feasibility of its idea. At the same time, juxtaposing LA's current situation with its speculative parallel, the project asked the viewers which scenario is more desirable, if either.

Car Pools asked how synthetic biology might be "domesticated" literally in our homes (track-specific **aspect 1**). The team imagined new social practices that might emerge from having your pool filled with algae. They experimented with "simulations" using non-engineered algae in baby pools in their yards throughout the summer, where they learned how to care for this living creature in their backyards.

Hardware Example and Measurement Example

Synthetic biology requires great hardware. Every synthetic biology experiment utilizes a variety of hardware, from liquid handling systems to centrifuges to culture machines and microscopes. Teams who develop a hardware-based project will be judged on how innovative their hardware systems are designed, fabricated, tested, and documented.

In synthetic biology, measurement is a critical challenge that is receiving an increasing amount of attention each year. For example, one of the long-standing goals of both iGEM and synthetic biology at large is to characterize biological parts so that they can be more easily used for designing new systems.

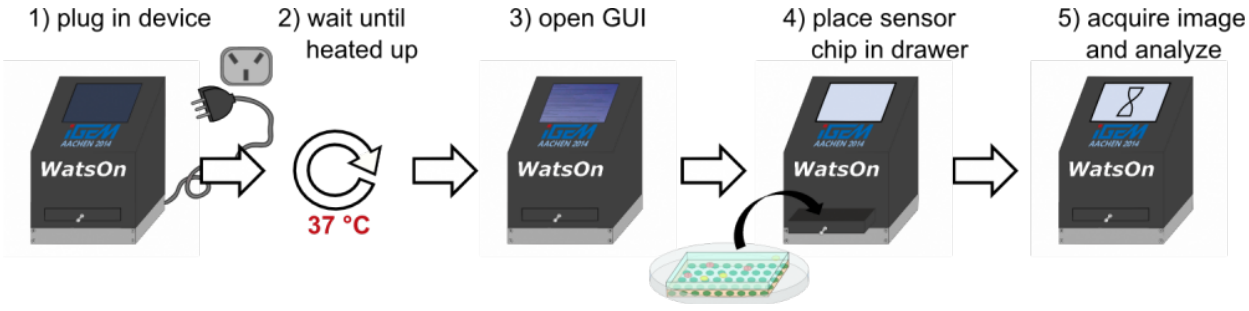
Aachen 2014

http://2014.igem.org/Team:Aachen

Measurement

Cellock Holmes, the 2014 Aachen project, aimed to detect bacteria on solid surfaces. As a part of this project, Team Aachen designed and built WatsOn, a proof-of-concept do-it-yourself 2D biosensing system (overview schematic shown below). The team used agar chips inoculated with sensing bacteria to determine if their system was capable of detecting other bacteria on a solid surface. The WatsOn system was built using a Raspberry Pi and an Arduino board, which controlled the excitation of LED lights and a Peltier heater for incubation. The team also implemented the WatsOn software complete with a graphical user interface, backend scripts running on the Raspberry Pi, and the code needed to run the Arduino board.

To complete this package, the team also created Measurarty, an image analysis software component used to interpret the images generated when the inoculated agar was placed inside WatsOn, where it was incubated and exposed to specific LED wavelengths. Combined, WatsOn functions as expected (described below) and can be built by end users for just over $300 USD, thus allowing researchers with limited funds a way to easily measure and quantify fluorescence. These areas of the project clearly address several key aspects (**aspects 1-6**).



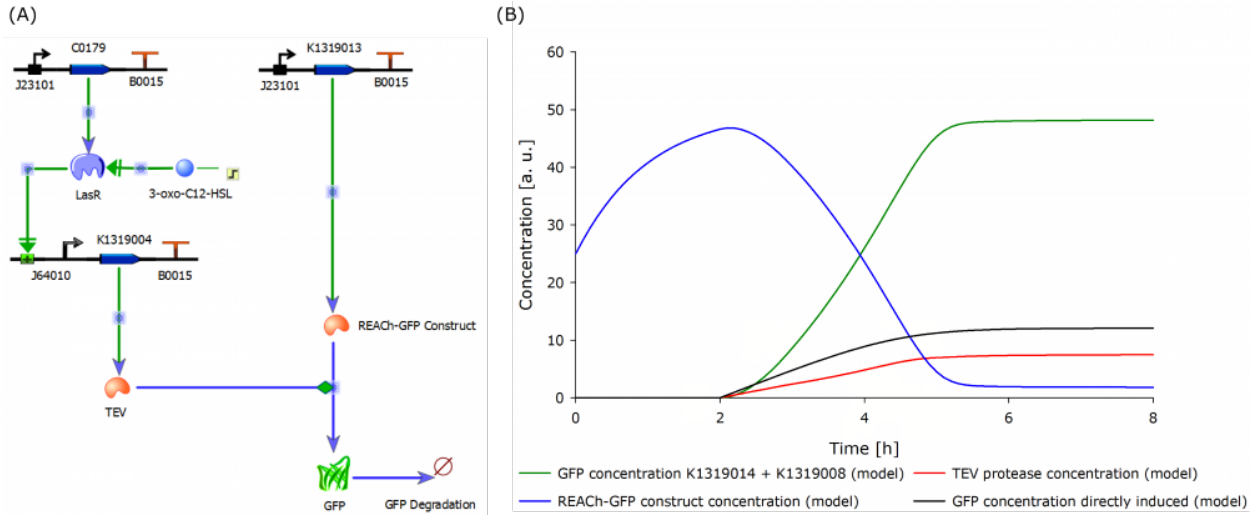
Hardware

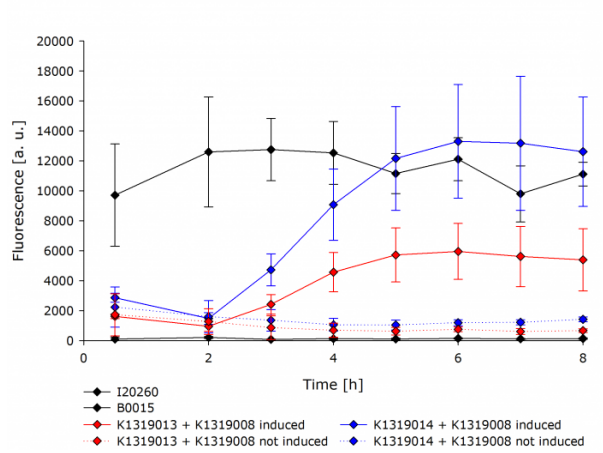
The hardware aspect of the Aachen project was only one part of their work. To detect the presence of bacteria with WatsOn, they needed to create a genetic device that would generate fluorescence.

The team chose *Pseudomonas aeruginosa* as their target organism due to the quorum sensing systems found naturally in *P. aeruginosa*. The team then engineered sensor *E. coli* cells, termed Cellocks, to detect *P. aeruginosa*'s native autoinducer (homoserine lactone, or HSL) and then output a fluorescent signal when HSL was detected.

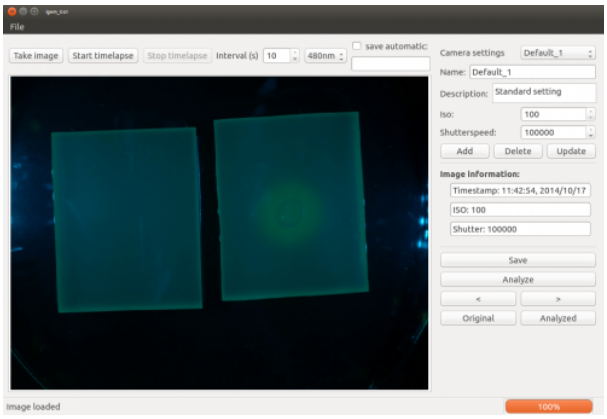
They also took the measurement of fluorescence seriously when designing the genetic devices for testing in the WatsOn system (**aspect 1**).

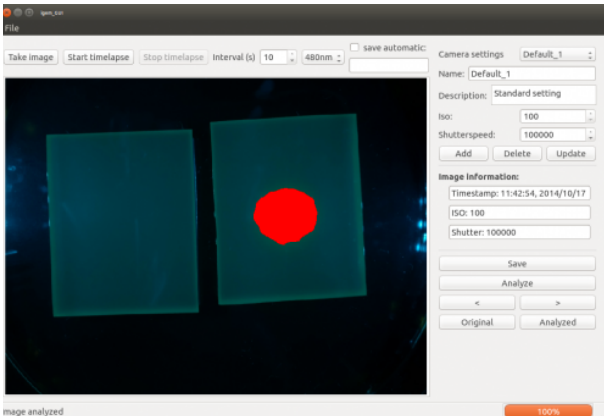
They designed a system that would bind with HSL and output green fluorescent protein (GFP), which they could then measure using WatsOn. Prior to testing these cells on WatsOn, Aachen measured the fluorescence using a plate reader to make sure their devices produced GFP in the presence of HSL; these data were also used to build and refine a model of their system.

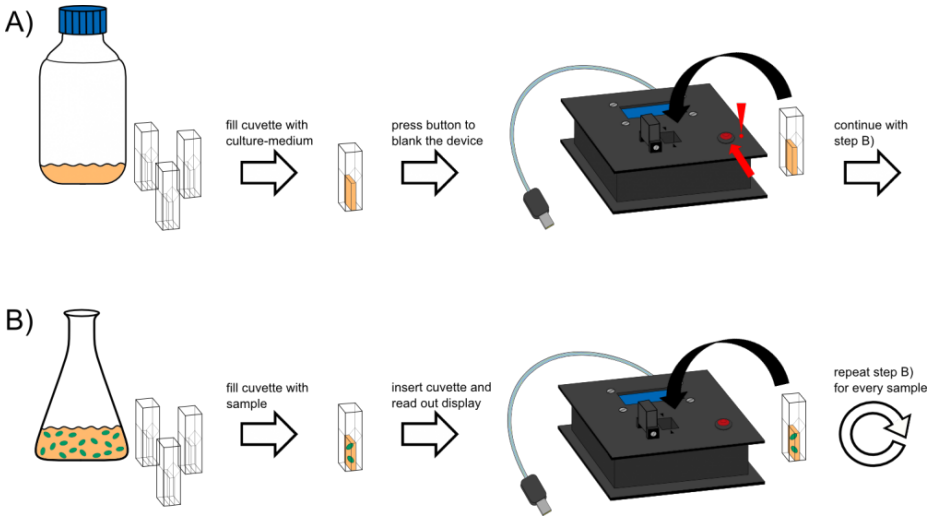


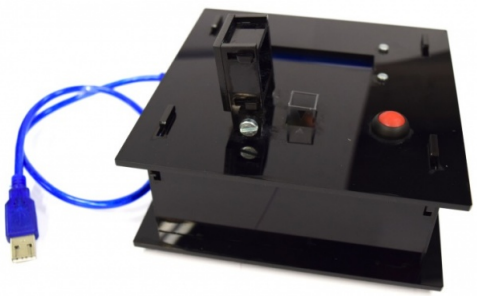


After determining the system worked in liquid culture, the team tested WatsOn using agar slabs seeded with their sensing cells. When P. aeruginosa was present, GFP was produced and clearly seen using WatsOn with and without the image analysis tool, Measurarty (left and right in next image, respectively).









While Cellocks Holmes was their main project, Aachen also developed a small OD/F Device for users to build themselves that can measure both optical density and fluorescence (see figure above). They were successful in designing, building, and testing a handheld OD/F Device for the cost of $60 USD (**aspects 3, 5, and 6**).

Aachen also explored policy and practices throughout their project. In particular, they took the safety concerns into account during the design of their system, attended a MakerFaire to exhibit their systems, and took the time to reach out and educate the public about synthetic biology (**aspect 7**).

Aachen's project was an impressively complete iGEM project where they executed a well engineered system, both biologically with bacteria and physically with hardware, and took into account the modeling of the biology as well as the safety issues surrounding their work. As a Measurement Track team, Aachen also participated in the InterLab study. In recognition of these achievements, Aachen won Best Measurement Project in 2014. They were also awarded Best Supporting Software, a Safety Commendation, and a Gold medal.

Software Track

Summary

- Software Track teams will create a novel software tool that supports some aspect of synthetic biology (e.g., methods, systems for representation of data, systems for data organization, etc.)
- Software should be freely available on GitHub such that anyone can view the code and its documentation.
- Excellent software tools should be novel, useful, and well documented.

The iGEM software track judging experience is a little different from that of the wet-lab tracks. You are judging a software tool, a user experience, a scientific project, a mountain of data, and any associated documentation about how the tool was built - all at the same time.

iGEM values software projects that produce, among other things:

- New scientific methods for synthetic biology
- New visual systems and methods of representing biological data
- New methods of organising, managing, or accessing biological data
- New methods of exchanging and updating data relevant to experiments or organisms
- Innovative approaches to implementing any of the above with novel code
- A team that is experienced in both software development and synthetic biology

Thanks to using software repositories like Github, judges are free to browse every single aspect of a software team's project. As such, judging this track can be a very involved process, and you should be prepared to interrogate the code and documentation of each team as much as possible. Ideally, judges should have opinions on code quality before seeing the team's presentation.

When judging software teams, consider projects on the merit of their ideas and the merit of their software. Oftentimes, obtaining data to use on a team's project can be difficult. You should expect to be able to use the software tool yourself, or at the very least be convinced that the tool is usable with a live demo.

When in doubt, ask the following questions and arrive at a decision:

- What was the overall quality of the tool?
- Has the team built a software tool that people would find useful?
- Is the software well designed for a synthetic biologist?
- Can I understand the documentation?
- Would a non-technical person understand the software?
- Would a software developer want to use this as a platform for more work?
- What part of the code did the team members write?
- Where did they use libraries?

Judges should look for teams that collaborated to solve wet-lab problems with software solutions. Judges should reward innovative approaches to tractable problems in synthetic biology. Wet-lab teams are very likely to have a problem that can be solved with good software, and so software track teams should attempt to provide additional solutions.

This collaboration will encourage software teams to hone their abilities in executing user experience testing, a core software development skill, as well as ensure that a biology team is directing the software team to build useful tools. Any experimental verification that comes out of this collaboration is a bonus.

Let's look at one Software Track team example.

USTC-Software 2014

http://2014.igem.org/Team:USTC-Software

BioPano is a software platform targeted for visualisation of biological relationships and cooperative net-building. It was built by UTSC-Software in 2014 to visualize the relationships between different DNA parts and solve the problem of unexpected host-BioBrick interactions (**aspect 1**).

The team introduced BioPano with a clear explanation that made use of a defined problem in experimental biology as well as a clear user need in the lab. The motivation for creating the tool was understandable by a non-technical individual.

USTC-Software demonstrated the relevance of their tool for synthetic biology based on standard parts. They built a "BioBrick Assistant" that allowed the user to directly enter precise numbers of standard parts and obtain parts types in "BioBrick Assistant Windows." The team made use of well-known pre-existing algorithms, and users could use the BLAST function within the BioBrick Assistant.

The team demonstrated utility for synthetic biologists by demonstrating that BioPano could, to some extent, predict the impact of a molecule on the host, and it could proactively warn against certain combinations of parts. The implied use of extensive rulesets was reflected in their code.

USTC-Software prepared a comprehensive and well-designed user guide and included it on their wiki (**aspect 2**). The guide provides details on all functions afforded to the user. In addition, other software developers are able to build on their work thanks to their detailed API documentation, which was automatically built using TOC. In general, teams should attempt to use automated documentation tools where possible.

Teams are encouraged to follow best practises in software development so that other developers can modify, use and reuse their code, with more than one realistic test case.

Examples of best practices are: automated unit testing and documentation of test coverage, bug tracking facilities, documentation of releases, and changes between releases. USTC-Software implemented automated deployment capabilities so that code pushed to their production branch would be deployed to all users within ten seconds, and also worked to employ automated testing on that code, to prevent bugs from surfacing for users.

In the case that bugs did make it through, users of BioPano could contact USTC-software, providing them with in-application links to YouTrack, a popular tool for bug tracking and feedback coordination. USTC-software also made their GitHub and GitLab account available to their users. Finally, their server applied automated unit testing to check the legitimacy and function of the code uploaded by a user.

USTC-Software provided a convincing and non-trivial validation of their tests - something which judges should always be looking out for - by demonstrating an analysis of the length of time their heuristic algorithm would take to find more than one path connected to two nodes in a given network. They did this using a pre-existing Python library.

Further, they made use of the SBOL format as users could explore data as an SBOL file, keeping in line with this requirement, and also linked nodes with experimental data gathered by other groups.

BioPano produced an incredible project that left all judges wowed in most cases (**aspects 1- 6**). It was complete, polished, well-thought out, documented, reusable, and professional. The tool could comfortably be used by a biologist wishing to explore the utility of Biobricks in certain hosts. In fact, it's quite hard to see why this wouldn't be an essential tool. The wiki was pretty, the demo video was useful, and the team met all specified requirements.

ACKNOWLEDGEMENTS

Acknowledgements

We are excited to present this Handbook to the judges this year and hope that it will be a valuable reference for both veteran and new judges. This resource would not have been possible without the help of many of our contributors. In particular, we would like to thank the efforts of Martha Eborall, King Chow, Roman Jerala, Raik Grünberg, Ed Perello, Gil Alterovitz, Jenhan Tao, Evan Appleton, Emma Frow, Megan Palmer, Dan Grushkin, Christina Agapakis, Will Canine, Dave Kong, Janet Standeven, Jacob Beal, Todd Kuiken, Sam Weiss Evans, Barbara Di Ventura, Markus Gershater, Tom Howard, George McArthur, Conny Scheitz, Kevin Chen, Dorothy Zhang, Marguerite Benony, Pieter van Boheeman, Matthew Sample, Kim de Mora, and Jason Kelly.

We also want to thank all of our committees for the countless hours they have worked to make iGEM even better this year. We have so many wonderful people who help out on our committees throughout the year and we are incredibly thankful for their contributions.

Finally, and most importantly, we want to thank you for volunteering your time to serve as a judge for the 2018 Giant Jamboree! Through the judging program, you are actively helping and guiding the next generation of synthetic biologists. Thank you so much for your time and effort! We appreciate everything that you've done for the iGEM students and hope you've enjoyed the experience.

We hope to see you back as a judge for 2019!

With sincere thanks,

The Executive Judging Committee and iGEM Headquarters